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3500 INDUSTRIAL and GENERATOR SET ENGINES

Maintenance Intervals

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Maintenance Recommendations

i02909163

System Pressure Release

SMCS Code: 1250; 1300; 1350; 5050

Coolant System

⚠ WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

High Pressure Fuel Lines (If Equipped)

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The high pressure fuel lines are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following differences:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.
2. Wait for ten minutes.

Do not loosen the high pressure fuel lines in order to remove air pressure from the fuel system.

Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

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Welding on Engines with Electronic Controls

SMCS Code: 1000

NOTICE
Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Caterpillar dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engine's ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the following procedure must be followed when you weld on a unit that is equipped with a Caterpillar Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

NOTICE
Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train, the bearings, hydraulic components, electrical components, and other components.

Do not ground the welder across the centerline of the package. Improper grounding could cause damage to the bearings, the crankshaft, the rotor shaft, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

3. Disconnect the J1/P1 and J2/P2 connectors from the ECM. Move the harness to a position that will not allow the harness to accidentally move back and make contact with any of the ECM pins.

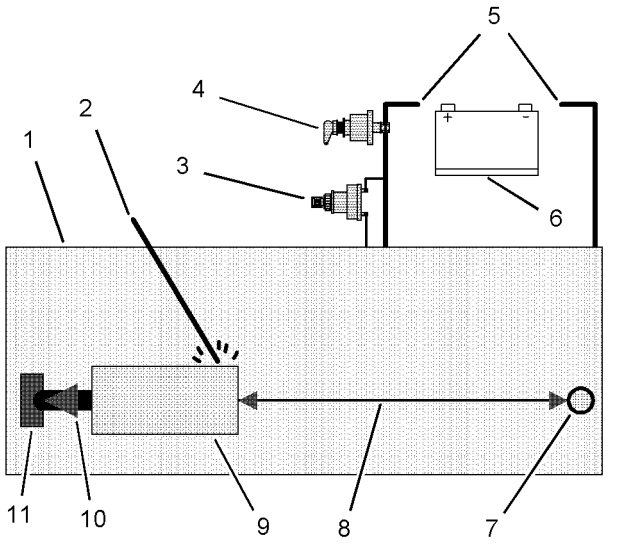

Illustration 44 g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not cause damage to any associated components.

(1) Engine
(2) Welding electrode
(3) Keyswitch in the OFF position
(4) Battery disconnect switch in the open position
(5) Disconnected battery cables
(6) Battery
(7) Electrical/Electronic component
(8) Minimum distance between the component that is being welded and any electrical/electronic component
(9) The component that is being welded
(10) Current path of the welder
(11) Ground clamp for the welder

4. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld in order to reduce the possibility of welding current damage to bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, or electrical/electronic components are located between the welder ground and the weld, current flow from the welder could severely damage the component.

5. Protect the wiring harness from welding debris and spatter.

6. Use standard welding practices to weld the materials.

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Maintenance Interval Schedule (Standby)

SMCS Code: 1000; 4450; 7500

Note: Ensure that the Safety Information, warnings, and instructions are read and understood before operation or maintenance procedures are performed.

Note: For information on generator maintenance, see the Operation and Maintenance Manual for the generator.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

When Required

Engine Air Cleaner Element (Dual Element) - Clean/Replace 79
Fuel System - Prime 94
Heat Exchanger - Inspect 98
Sea Water Strainer - Clean/Inspect 111
Standby Generator Set Maintenance Recommendations 111

Every Week

Air Starting Motor Lubricator Oil Level - Check 64
Air Tank Moisture and Sediment - Drain 64
Automatic Start/Stop - Inspect 65
Battery Charger - Check 67
Battery Electrolyte Level - Check 67
Cooling System Coolant Level - Check 73
Engine Air Cleaner Service Indicator - Inspect 84
Engine Air Precleaner - Clean 85
Engine Oil Filter Differential Pressure - Check 86
Engine Oil Level - Check 87
Fuel System Fuel Filter Differential Pressure - Check 94
Fuel Tank Water and Sediment - Drain 97
Instrument Panel - Inspect 102
Jacket Water Heater - Check 102
Radiator - Clean 110
Starting Motor - Inspect 112
Walk-Around Inspection 113
Walk-Around Inspection 114

Every Year

Actuator Control Linkage - Lubricate 62
Air Starting Motor Lubricator Bowl - Clean 63
Alternator - Inspect 65
Belts - Inspect/Adjust/Replace 68
Cooling System Coolant Sample (Level 2) - Obtain 75
Cooling System Supplemental Coolant Additive (SCA) - Test/Add 75
Crankshaft Vibration Damper - Inspect 77
Engine - Clean 78
Engine Air Cleaner Element (Single Element) - Clean/Replace 81
Engine Crankcase Breather - Clean 85
Engine Mounts - Check 86
Engine Oil Sample - Obtain 87
Engine Oil and Filter - Change 88
Engine Performance - Test 93
Engine Protective Devices - Check 93
Engine Valve Lash - Inspect/Adjust 93
Fan Drive Bearing - Lubricate 94
Fuel Injector - Inspect/Adjust 94
Fuel System Secondary Filter - Replace 95
Hoses and Clamps - Inspect/Replace 100
Magnetic Pickups - Clean/Inspect 102

Every 3 Years

Batteries - Replace 66
Belts - Replace 69
Cooling System Coolant (DEAC) - Change 69
Cooling System Coolant Extender (ELC) - Add 73
Cooling System Water Temperature Regulator - Replace 77
Hoses and Clamps - Replace 101
Turbocharger - Inspect 112
Water Pump - Inspect 115

Every 6 Years

Cooling System Coolant (ELC) - Change 71

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Maintenance Interval Schedule (Standard)

SMCS Code: 1000; 4450; 7500

Note: Ensure that the Safety Information, warnings, and instructions are read and understood before operation or maintenance procedures are performed.

Note: For information on generator maintenance, see the Operation and Maintenance Manual for the generator.

All of the following will affect the oil change interval: operating conditions, fuel type, oil type, and size of the oil sump . Scheduled oil sampling analyzes used oil in order to determine if the oil change interval is suitable for your specific engine.

In the absence of scheduled oil sampling, change the engine oil and filters according to the following intervals:

If the engine has a Shallow Oil Sump, change the oil after every 250 service hours.

If the engine has a Standard Oil Sump, change the oil after every 500 service hours.

If the engine has a Deep Oil Sump, change the oil after every 1000 service hours.

Refer to this Operation and Maintenance Manual, “Engine Oil and Filter - Change” in order to determine the oil change interval that is suitable for your specific engine.

Note: To determine the maintenance intervals for overhauls, refer to this Operation and Maintenance Manual, “Overhaul Considerations” .

Note: Use service hours, or calendar time, which ever occurs first , in order to determine the maintenance intervals. Engines that operate in severe operating conditions may require more frequent maintenance.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

When Required

Batteries - Replace 66
Engine Air Cleaner Element (Dual Element) - Clean/Replace 79
Engine Air Cleaner Element (Single Element) - Clean/Replace 81
Fuel System - Prime 94
Heat Exchanger - Inspect 98
Sea Water Strainer - Clean/Inspect 111
Zinc Rods - Inspect/Replace 115

Daily

Air Starting Motor Lubricator Oil Level - Check 64
Air Tank Moisture and Sediment - Drain 64
Cooling System Coolant Level - Check 73
Engine Air Cleaner Service Indicator - Inspect 84
Engine Air Precleaner - Clean 85
Engine Oil Filter Differential Pressure - Check 86
Engine Oil Level - Check 87
Fuel System Fuel Filter Differential Pressure - Check 94
Fuel Tank Water and Sediment - Drain 97
Instrument Panel - Inspect 102
Walk-Around Inspection 113

Initial 250 Service Hours (or at first oil change)

Engine Valve Lash - Inspect/Adjust 93
Fuel Injector - Inspect/Adjust 94
Magnetic Pickups - Clean/Inspect 102

Every 250 Service Hours

Battery Electrolyte Level - Check 67
Belts - Inspect/Adjust/Replace 68
Cooling System Coolant Sample (Level 1) - Obtain 74
Cooling System Supplemental Coolant Additive (SCA) - Test/Add 75
Engine Oil Sample - Obtain 87
Engine Oil and Filter - Change 88
Fan Drive Bearing - Lubricate 94
Hoses and Clamps - Inspect/Replace 100
Radiator - Clean 110

Every 500 Service Hours

Air Shutoff - Test 62
Engine Oil and Filter - Change 88

Every 1000 Service Hours

Engine - Clean 78
Engine Crankcase Breather - Clean 85
Engine Oil and Filter - Change 88
Engine Protective Devices - Check 93
Fuel System Secondary Filter - Replace 95

Every 2000 Service Hours

Actuator Control Linkage - Lubricate 62
Air Starting Motor Lubricator Bowl - Clean 63
Crankshaft Vibration Damper - Inspect 77
Engine Mounts - Check 86

Every Year

Cooling System Coolant Sample (Level 2) - Obtain 75

Every 3000 Service Hours or 3 Years

Cooling System Coolant (DEAC) - Change 69

Every 4000 Service Hours

Auxiliary Water Pump - Inspect 65
Engine Valve Lash - Inspect/Adjust 93
Fuel Injector - Inspect/Adjust 94

Every 6000 Service Hours or 3 Years

Cooling System Coolant Extender (ELC) - Add 73

Every 6000 Service Hours or 6 Years

Alternator - Inspect 65
Cooling System Water Temperature Regulator - Replace 77
Magnetic Pickups - Clean/Inspect 102
Starting Motor - Inspect 112
Turbocharger - Inspect 112
Water Pump - Inspect 115

Every 12 000 Service Hours or 6 Years

Cooling System Coolant (ELC) - Change 71

Overhaul

Overhaul (Major) 102
Overhaul (Top End) 104
Overhaul Considerations 106

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Actuator Control Linkage - Lubricate

SMCS Code: 1265-086

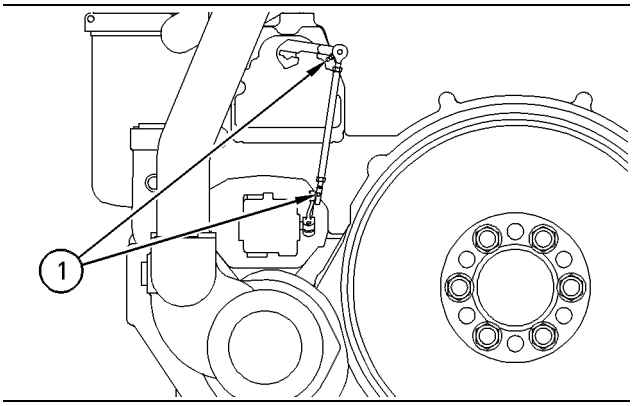

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Illustration 45

(1) Grease Fitting

Apply grease to the grease fittings (1).

Use a hand grease gun and lubricate the grease fittings with MPGM.

Check the Linkage

Use the following procedure to check the linkage for binding.

1. Stop the engine.
2. Move the linkage by hand.

   If the linkage binds, repair the linkage.

For information on adjustment, removal, and replacement, see the Service Manual. Consult your Caterpillar dealer for assistance.

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Air Shutoff - Test

SMCS Code: 1078-081

Air shutoff valves must be tested and inspected in order to ensure proper operation. Before testing, remove each limit switch and inspect each limit switch assembly for wear. The typical wear is erosion of the plunger. This is due to vibration of the plunger within the bore for the plunger. This usually causes the switch to jam or this causes the switch to become otherwise inoperable.

Note: The limit switches are normally open switches. The switches are in the closed state when the air shutoff valves are latched in the open, or Run position. If the air shutoff valve is in the Closed position or the Stop position, the switch is in the open state, which will cause an emergency stop. This will shut down the engine or this will prevent the engine from starting. The engine will crank but the engine will not start.

Electrically Operated Air Shutoff Valves

1. Power up the engine control panel with both air shutoff valves latched in the open position and both switches connected. Both valves should remain open. Check the wiring for the switch if both valves do not remain open.
2. With the power to the engine control panel ON, activate the emergency stop button. Both of the air shutoff valves should close. If both air shutoff valves do not close, check the switch wiring and the solenoid wiring. If both air shutoff valves close, proceed to step 3.
3. Turn the power engine control panel to the OFF position. Ensure that the emergency stop button is in the run position. Latch only the right side air shutoff valve to the open position and turn the power for the engine control panel to the ON position. The right air shutoff valve should close. If the right air shutoff valve closes proceed to step 4. If the right air shutoff valve does not close, check the switch and wiring for the right air shutoff valve.
4. Turn power for the engine control panel to the OFF position. Ensure that the emergency stop button is in the run position. Latch only the left side air shutoff valve to the open position. Turn the power for the engine control to the ON position. The left air shutoff valve should close. If the left air shutoff valve closes the test is complete. If the left air shutoff valve does not close, check the switch and the wiring for the left air shutoff valve.

Note: Testing is only complete when the engine successfully passes step 1 through step 4.

Hydraulically Actuated Air Shutoff Valves

Note: After checking the fluids in the engine, ensure that both air shutoff valves are latched in the open position. Start the engine and operate the engine at 1500 RPM. This will allow the fluids to warm up before proceeding with the test for the air shutoff valves.

1. Manually trip one of the air shutoff valves. This should cause an emergency stop condition and the remaining air shutoff valve should close. If the engine experienced an emergency stop condition but the remaining valve did not close, purge the air from the line that goes to the hydraulic cylinder for the air shutoff valve. If the engine did not have an emergency stop condition the switches are not correctly wired into the emergency stop circuit.

Note: Both switches should be in a closed state and both switches should show continuity when the air shutoffs are latched in the open position. After the issue with the wiring has been resolved repeat step 1.

2. Close one air shutoff valve and attempt to start the engine. If the engine cranks but the engine will not start, the switches are functioning correctly. Caterpillar Electronic Technician (ET) will also show an active emergency stop condition. Proceed to step 3. If the engine starts with one of the air shutoffs closed, check the switch on the valve that is closed. The switch should not have continuity. If the switch has continuity, remove the switch and inspect the switch. If the switch does not show continuity, troubleshoot the switch wiring further. Repair the necessary components or replace the necessary components. Retest the system, as required.

3. With both air shutoff valves in the open position, activate the emergency stop. Both air shutoff valves should close. If both valves close, testing is complete. If only one air shutoff closes, purge air from the line at the cylinder that failed to close and repeat this step.

Note: Testing is only complete when the engine successfully passes all of the steps. Reset both air shutoff valves to the open position and clean up any spills that may have occurred.

Note: The limit switch assemblies are items that wear and the limit switch assemblies may need to be replaced during normal maintenance intervals.

i02654935

Air Starting Motor Lubricator Bowl - Clean

SMCS Code: 1451-070

If the engine is equipped with an air starting motor, use the following procedure:

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

1. Ensure that the air supply to the lubricator is OFF.

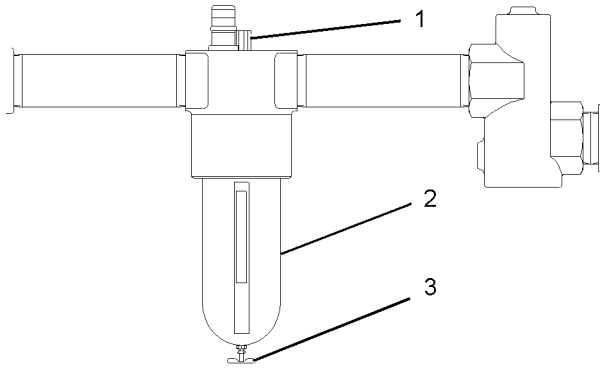

Illustration 46 g01333332

(1) Filler plug
(2) Bowl
(3) Drain valve

2. Slowly loosen filler plug (1) in order to release the pressure from the lubricator.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

3. Place a suitable container under bowl (2) and open drain valve (3) in order to drain the oil from the bowl.

4. Remove bowl (2). Clean the bowl with warm water.

5. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl. Inspect the gasket. If the gasket is damaged, replace the gasket.

6. Install the bowl.

7. Make sure that drain valve (3) is closed.

8. For instructions on filling the lubricator, see this Operation and Maintenance Manual, “Air Starting Motor Lubricator Oil Level - Check” topic.

i02654969

Air Starting Motor Lubricator Oil Level - Check

SMCS Code: 1451-535

NOTICE
Never allow the lubricator bowl to become empty. The air starting motor will be damaged by a lack of lubrication. Ensure that sufficient oil is in the lubricator bowl.

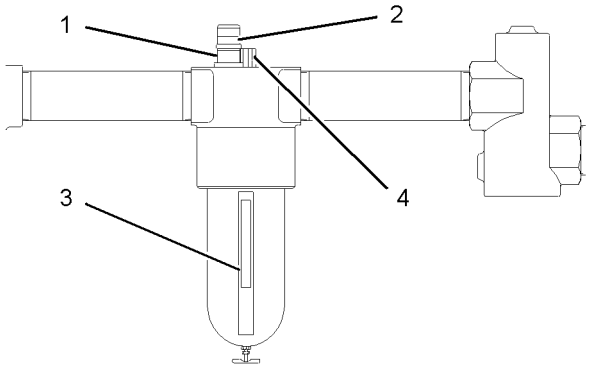

Illustration 47 g01333366

1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

2. Ensure that the air supply to the lubricator is OFF. Slowly loosen filler plug (4) in order to release pressure from the lubricator bowl.

3. Remove filler plug (4). Pour oil into the lubricator bowl. Use nondetergent SAE 10W oil for temperatures that are greater than 0 °C (32 °F). Use air tool oil for temperatures that are below 0 °C (32 °F).

4. Install filler plug (4).

Adjust the Lubricator

Note: Adjust the lubricator with a constant rate of air flow. After the adjustment, the lubricator will release oil in proportion to variations of the air flow.

1. Ensure that the fuel supply to the engine is OFF.

NOTICE
Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

2. Operate the air starting motor. Observe the drops of oil that are released in dome (1).

Note: Some lubricators have an adjustment screw rather than a knob.

3. If necessary, adjust the lubricator in order to release from one to three drops of oil per second. To increase the rate, turn knob (2) counterclockwise. To decrease the rate, turn the knob clockwise.

i00351324

Air Tank Moisture and Sediment - Drain

SMCS Code: 1466-543-M&S

Moisture and sediment in the air starting system can cause the following conditions:

- Freezing
- Corrosion of internal parts
- Malfunction of the air starting system

⚠ WARNING

When opening the drain valve, wear protective gloves, a protective face shield, protective clothing, and protective shoes. Pressurized air could cause debris to be blown and result in personal injury.

1. Open the drain valve that is on the bottom of the air tank. Allow the moisture and sediment to drain.

2. Close the drain valve.

i02084374

Alternator - Inspect

SMCS Code: 1405-040

Inspect the alternator for the following conditions:

- Proper connections
- Clean ports for cooling airflow
- Proper charging of the battery

Observe the ammeter during engine operation in order to ensure proper battery performance and/or proper performance of the electrical system.

Make repairs, if necessary. See the Service Manual for service procedures. Consult your Caterpillar dealer for assistance.

i01039675

Automatic Start/Stop - Inspect (Generator Set)

SMCS Code: 4462

The generator set must be ready to operate under a load at any time. After performing maintenance on the generator set, inspect the position of the control switches. Ensure the following conditions:

- The starting system is enabled.
- The control switches are in the correct position for automatic starting.
- The switchgear and the automatic transfer switches that are associated with the generator are enabled.

For more information, see the Operation and Maintenance Manual for the generator and the control panel.

i02346673

Auxiliary Water Pump - Inspect (if equipped)

SMCS Code: 1371-040; 1371

Impellers and seals require periodic inspection. Impellers have a service life that is limited. The service life depends on the engine operating conditions.

Inspect the components more frequently when the pump is exposed to debris, sand, or other abrasive materials. Inspect the components if the pump is operating at a differential pressure of more than 103 kPa (15 psi).

There are different types of pumps. Some pumps will have a cover that is bolted to the main pump body. Some pumps will have a clamp that holds the front part of the pump body to the main part of the pump body. The cover or the front part of the pump body must be removed in order to inspect the pump.

Pumps with a Cover

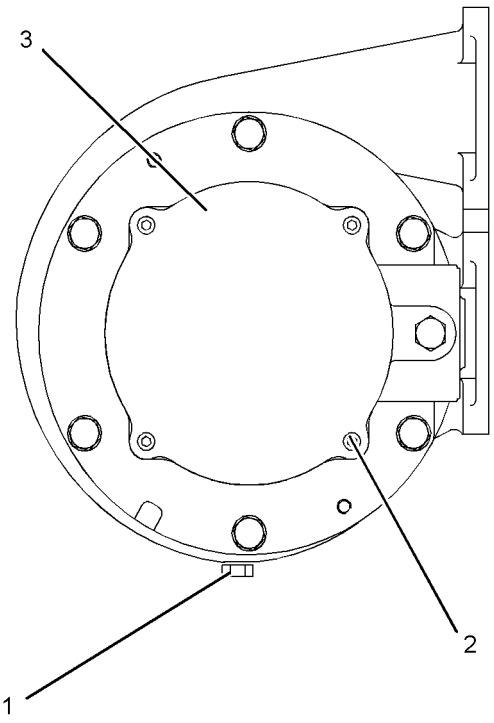

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Illustration 48

(1) Plug
(2) Bolt
(3) Cover

1. Remove plug (1) and drain the water out of the pump.

2. Remove bolts (2) and cover (3).

3. Inspect the priming impeller, the wear plates for the priming impeller and the impeller for wear or damage. Inspect the pump housing for wear, damage or buildup.

4. Inspect the pump shaft and the impeller for excessive axial movement.

5. If wear or damage is found, replace the components which are worn or damaged. Use the proper repair kit for the pump.

Pumps with a Clamp

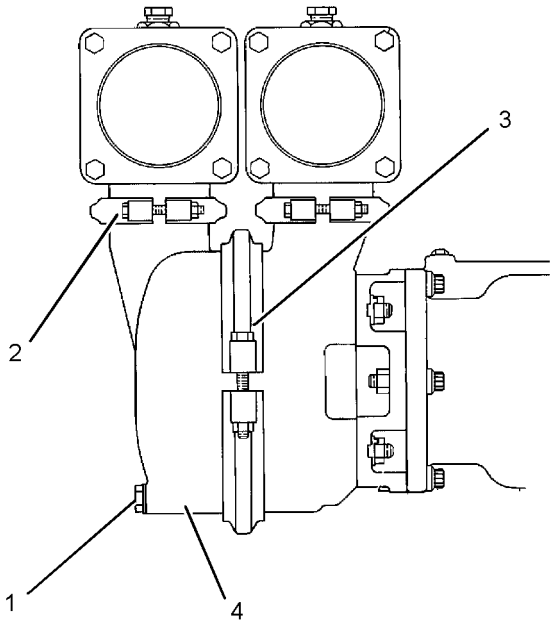


Illustration 49 g01136382

(1) Plug
(2) Clamp
(3) Clamp
(4) Front part of the pump body

1. Remove plug (1) and drain the water out of the pump.

2. Remove the water line and clamp (2), if necessary.

3. Loosen clamp (3) and remove the front part of the pump body (4).

4. Inspect the impeller, the wear plates and the wear ring for wear or damage. Inspect the pump housing for wear, damage or buildup.

5. Inspect the pump shaft and the impeller for excessive axial movement.

6. If wear or damage is found, replace the components which are worn or damaged. Use the proper repair kit for the pump.

i01041029

Batteries - Replace

SMCS Code: 1401-510

⚠ WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.

2. Turn OFF the battery charger. Disconnect the charger.

3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.

4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Return used batteries to an appropriate recycling facility.

5. Remove the used battery.

6. Install the new battery.

Note: Before connecting the cables, ensure that the key start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.

8. Connect the cable from the ground plane to the NEGATIVE “-” battery terminal.

i01039758

Battery Charger - Check

SMCS Code: 1401-535

Checking Before Start-Up

Check the battery charger for proper operation. If the batteries are properly charged, the needle of the ammeter will register near “0” (zero).

The battery charger must not produce excessive current during start-up. Alternatively, the charger must be automatically disconnected for start-up. If the engine has an alternator, the charger must be automatically disconnected during start-up and during engine operation.

Charging the Battery

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

Perform the following procedure to charge the battery:

1. Ensure that the charger is turned OFF.
2. Adjust the voltage of the charger in order to match the voltage of the battery.
3. Connect the POSITIVE “+” lead of the charger to the POSITIVE “+” battery terminal. Connect the NEGATIVE “-” lead of the charger to the NEGATIVE “-” battery terminal.
4. Turn ON the battery charger.

Overcharging of Batteries

Overcharging reduces the service life of batteries. Use a battery charger that will not overcharge the battery. DO NOT charge the battery if the meter of the battery charger is in the RED zone.

Overcharging is indicated by the following symptoms:

- The battery is very warm to the touch.
- A strong odor of acid is present.
- The battery emits smoke or a dense vapor (gas).

Perform one of the following procedures if the battery shows symptoms of overcharging:

- Reduce the rate of charging by a significant amount. Complete the charging at the reduced rate.
- Turn OFF the charger.

Table 15 describes the effects of overcharging on different types of batteries.

Table 15

Effects of Overcharging Batteries	
Type of Battery	**Effect**
Caterpillar General Service Batteries Caterpillar Premium High Output Batteries	All of the battery cells have a low level of electrolyte.
	When the plates of the battery are inspected through the filler holes, the plates may appear to be warped. This is caused by an excessive temperature.
	The battery may not pass a load test.
Caterpillar Maintenance Free Batteries	The battery may not accept a charging current.
	The battery may not pass a load test.

Checking After Stopping

Ensure that the battery charger is connected properly. Observe the meter of the charger. Record the amperage.

i02601752

Battery Electrolyte Level - Check

SMCS Code: 1401-535-FLV

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with the 245-5829 Coolant Battery Tester Refractometer.

3. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
   - A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water

   Thoroughly rinse the battery case with clean water.

   Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit properly. Coat the clamps and the terminals with 5N-5561 Silicone Lubricant, petroleum jelly or MPGM.

i02667833

Belts - Inspect/Adjust/Replace

SMCS Code: 1357-025; 1357-040; 1357-510

Inspection

Inspect the alternator belt and the fan drive belts for wear and for cracking. Replace the belts if the belts are not in good condition.

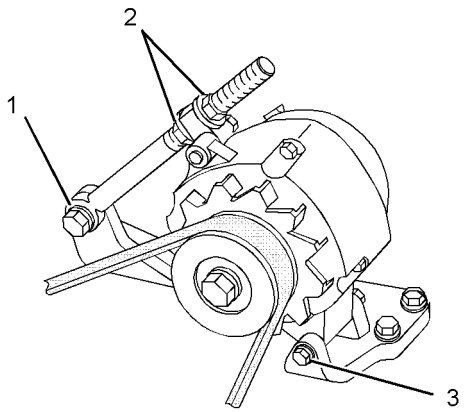
Check the belt tension according to the information in the Service Manual, “Specifications”.

Slippage of loose belts can reduce the efficiency of the driven components. Vibration of loose belts can cause unnecessary wear on the following components:

- Belts
- Pulleys
- Bearings

If the belts are too tight, unnecessary stress is placed on the components. This reduces the service life of the components.

Adjusting the Alternator Belt



g01092641

Illustration 50

Typical alternator

(1) Mounting bolt
(2) Adjusting nuts
(3) Mounting bolt

1. Remove the drive belt guard.
2. Loosen mounting bolt (1), adjusting nuts (2) and mounting bolt (3).
3. Turn adjusting nuts (2) in order to increase or decrease the drive belt tension.
4. Tighten adjusting nuts (2). Tighten mounting bolt (3). Tighten mounting bolt (1). For the proper torque, see the Service Manual, “Specifications” module.
5. Reinstall the drive belt guard.

If new drive belts are installed, check the drive belt tension again after 30 minutes of engine operation at the rated rpm.

Adjusting the Fan Drive Belt

1. Loosen the mounting bolt for the pulley.
2. Loosen the adjusting nut for the pulley.

3. Move the pulley in order to adjust the belt tension.

4. Tighten the adjusting nut to the proper torque.

5. Tighten the mounting bolt to the proper torque.

For the proper torque specifications, refer to the Service Manual, “Specifications” module.

Replacement

For applications that require multiple drive belts, replace the drive belts in matched sets. Replacing one drive belt of a matched set will cause the new drive belt to carry more load because the older drive belts are stretched. The additional load on the new drive belt could cause the new drive belt to fail.

i01041135

Belts - Replace

SMCS Code: 1357-510

Remove the used fan drive belt and the accessory drive belt. Install new belts.

For applications that require multiple drive belts, replace the belts in matched sets. Used belts are stretched. Replacing only one belt of a matched set will cause the new belt to carry an excessive load. The additional load on the new belt could cause the new belt to break.

Check the belt tension according to the information in the Service Manual, “Specifications” module. To adjust the belt tension, see this Operation and Maintenance Manual, “Alternator and Fan Belts - Inspect/Adjust/Replace” topic (Maintenance Section).

After new belts are installed, check the belt tension again after 30 minutes of engine operation at rated rpm.

i02417350

Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-044

Clean the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- The coolant is foaming.
- Oil or fuel has entered the cooling system and the coolant is contaminated.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

2. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.

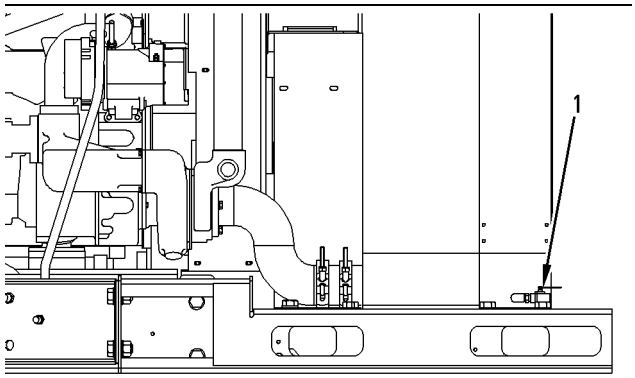


Illustration 51 g00750410

(1) Coolant drain

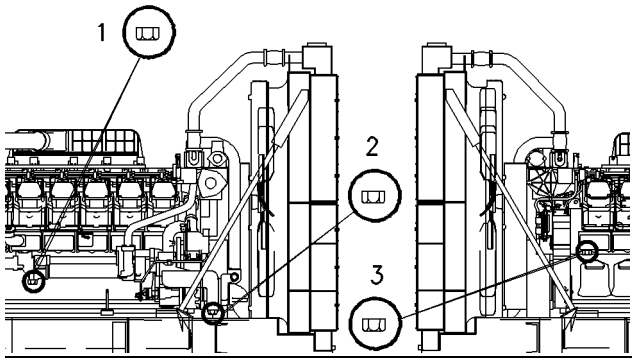


Illustration 52 g00750411

Locations of the cooling system drain plugs

(1) Oil cooler
(2) Jacket water pump
(3) Engine block

Note: If the engine has a jacket water heater, drain the coolant from the heater.

3. Open the coolant drain. Remove the cooling system drain plugs. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Dealer Service Tools Group:

Outside U.S.A.: (309) 675-6277
Inside U.S.A.: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
CSTG COSA Geneva, Switzerland:
41-22-849 40 56

Clean the Cooling System

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the radiator filler cap.

4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs. Open the water inlet for the separate circuit aftercooler (if equipped).

Cleaning a Cooling System that has Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be an active flow through the cooling system components.

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the coolant drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the radiator filler cap.

4. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap. Open the coolant drain. Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain. Clean the cooling system drain plugs and install the cooling system drain plugs.

Fill the Cooling System

Note: For information about the proper coolant to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section). For the capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system with coolant/antifreeze. After filling the cooling system, do not install the radiator filler cap.

2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the coolant to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.

4. Clean the radiator filler cap. Inspect the gaskets of the radiator filler cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02417402

Cooling System Coolant (ELC) - Change

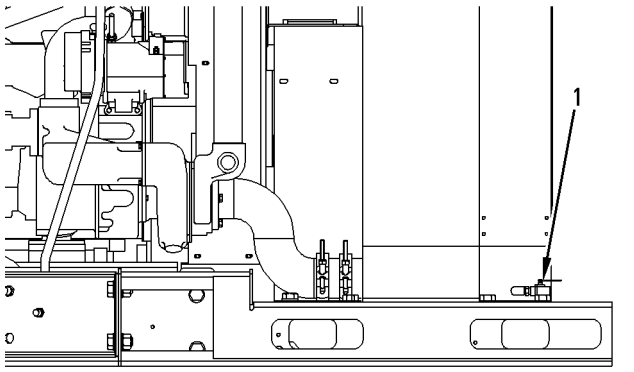
SMCS Code: 1350-044-NL

Use only clean water to flush the cooling system when ELC (Extended Life Coolant) is drained and replaced.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained.

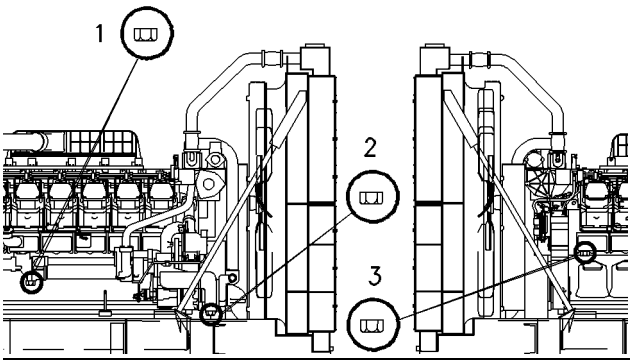
2. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.



g00750410

Illustration 53

(1) Coolant drain



g00750411

Illustration 54

Locations of the cooling system drain plugs

(1) Oil cooler
(2) Jacket water pump
(3) Engine block

Note: If the engine has a jacket water heater, drain the coolant from the heater.

3. Open the coolant drain. Remove the cooling system drain plugs. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Dealer Service Tools Group:

Outside U.S.A.: (309) 675-6277
Inside U.S.A.: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
CSTG COSA Geneva, Switzerland:
41-22-849 40 56

Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the coolant drain. Clean the drain plugs and install the drain plugs.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Open the water inlet for the separate circuit aftercooler (if equipped). Fill the cooling system with clean water. Install the radiator filler cap. Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).

4. Stop the engine and allow the engine to cool. Close the water inlet for the separate circuit aftercooler (if equipped). Ensure that the engine will not start when the cooling system is drained. Loosen the radiator filler cap slowly in order to relieve any pressure. Remove the radiator filler cap.

5. Open the coolant drain. Remove the drain plugs. Allow the coolant to drain. Flush the cooling system with clean water. Close the coolant drain. Install the drain plugs.

6. Repeat Steps 3, 4, and 5.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

1. Fill the cooling system with ELC (Extended Life Coolant). After filling the cooling system, do not install the radiator filler cap.

2. Open the water inlet for the separate circuit aftercooler (if equipped). Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the ELC to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.

4. Clean the radiator filler cap. Inspect the gaskets of the radiator cap. If the gaskets of the radiator filler cap are damaged, discard the old radiator filler cap and install a new radiator filler cap. If the gaskets of the radiator filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the radiator filler cap. The correct pressure is stamped on the face of the radiator filler cap. If the radiator filler cap does not maintain the correct pressure, install a new radiator filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02482066

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Cat ELC (Extended Life Coolant) does not require the frequent additions of any supplemental cooling additives which are associated with the present conventional coolants. The Cat ELC Extender only needs to be added once.

NOTICE
Use only Cat Extended Life Coolant (ELC) Extender with Cat ELC.

Do NOT use conventional supplemental coolant additive (SCA) with Cat ELC. Mixing Cat ELC with conventional coolants and/or conventional SCA reduces the Cat ELC service life.

Check the cooling system only when the engine is stopped and cool.

⚠ WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove cooling system pressure cap slowly to relieve pressure only when engine is stopped and cooling system pressure cap is cool enough to touch with your bare hand.

Do not attempt to tighten hose connections when the coolant is hot, the hose can come off causing burns.

Cooling System Coolant Additive contains alkali. Avoid contact with skin and eyes.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.
2. It may be necessary to drain enough coolant from the cooling system in order to add the Cat ELC Extender.
3. Add Cat ELC Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” article for more information.
4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i02158408

Cooling System Coolant Level - Check

SMCS Code: 1350-535-FLV

⚠ WARNING

Climbing equipment may be required to access this service point. Refer to the Operation and Maintenance Manual, “Mounting and Dismounting” topic for safety information.

Engines That Are Equipped With a Sight Gauge

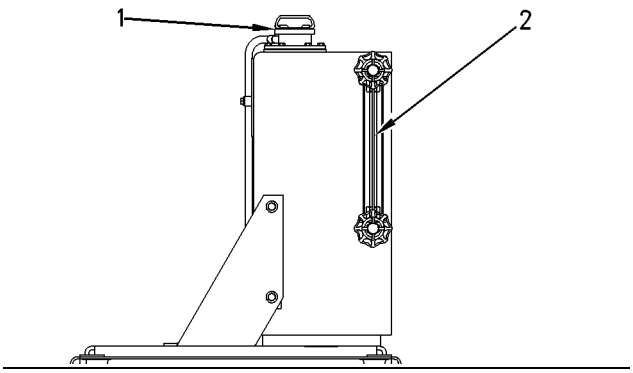


Illustration 55 g00750429

(1) Filler cap
(2) Sight gauge

If the engine is equipped with a sight gauge, observe the position of the coolant in the sight gauge. At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the proper coolant mixture.

Engines That Are Not Equipped With a Sight Gauge

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

Check the coolant level when the engine is stopped and cool. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Remove the cooling system filler cap slowly in order to relieve any pressure. Maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe.

Add Coolant

Note: For the proper coolant mixture to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

1. Stop the engine. Allow the engine to cool.
2. Remove the cooling system filler cap slowly in order to relieve any pressure. Pour the proper coolant mixture into the filler pipe.

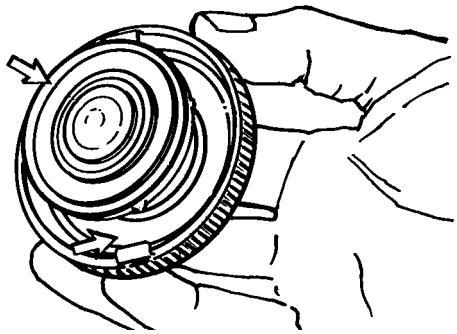


Illustration 56 g00103639

Gaskets

3. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.
4. Start the engine. Inspect the cooling system for leaks.

i02837191

Cooling System Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

Note: Obtaining a Coolant Sample (Level 1) is optional if the cooling system is filled with Cat ELC (Extended Life Coolant). Cooling systems that are filled with Cat ELC should have a Coolant Sample (Level 2) that is obtained at the recommended interval that is stated in the Maintenance Interval Schedule.

Note: Obtain a Coolant Sample (Level 1) if the cooling system is filled with any other coolant instead of Cat ELC. This includes the following types of coolants:

- Commercial long life coolants that meet the Caterpillar Engine Coolant Specification -1 (Caterpillar EC-1)
- Cat DEAC (Diesel Engine Antifreeze/Coolant)
- Commercial heavy-duty coolant/antifreeze

Table 16

Recommended Interval		
Type of Coolant	**Level 1**	**Level 2**
Cat DEAC	Every 250 Hours(1)	Yearly(1)(2)
Cat ELC	Optional(2)	Yearly(2)

(1) This is the recommended interval for coolant samples for all conventional heavy-duty coolant/antifreeze. This is also the recommended interval for coolant samples of commercial coolants that meet the Cat EC-1 specification for engine coolant.

(2) The Level 2 Coolant Analysis should be performed sooner if a problem is suspected or identified.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Note: Level 1 results may indicate a need for Level 2 Analysis.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. In order to receive the full effect of S·O·S analysis, you must establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Caterpillar dealer.

Use the following guidelines for proper sampling of the coolant:

- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Keep the unused sampling bottles stored in plastic bags.
- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Place the sample in the mailing tube immediately after obtaining the sample in order to avoid contamination.
- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.

Submit the sample for Level 1 analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” or consult your Caterpillar dealer.

i01987714

Cooling System Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Refer to Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engines Fluids Recommendations” or consult your Caterpillar dealer.

i02839449

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

⚠ WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.

NOTICE
Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

Excessive supplemental coolant additive concentration could also result in blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

Do not exceed the recommended amount of supplemental coolant additive concentration.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” and to Special Publication, GECJ0003, “Cat Shop Supplies and Tools” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to applicable regulations and mandates.

Note: Caterpillar recommends an S·O·S coolant analysis (Level 1).

Cooling Systems that Use Conventional Coolant

This maintenance procedure is required for conventional coolants such as DEAC.**This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.**

Test the Concentration of the SCA

NOTICE
Do not exceed the recommended six percent supplemental coolant additive concentration.

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit.

Add the SCA, If Necessary

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic. The proper concentration of SCA depends on the type of coolant that is used. For the proper concentration of SCA, refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”.
4. Clean the cooling system filler cap. Install the cooling system filler cap.

Cooling Systems that Use Water and SCA

Test the Concentration of the SCA

Test the concentration of the SCA with a 298-5311 Coolant Nitrite Test Kit for SCA or perform an S·O·S Coolant Analysis. The test kit includes the following items: a tool for the testing, 30 ampoules for testing nitrite, instructions, and a case. 294-7420 Test Kit contains the refill ampoules for the 298-5311 Coolant Nitrite Test Kit. Use the instructions that are included with the test kit in order to properly conduct the testing.

Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the times at which the procedures should be conducted. Test the concentration of the SCA more frequently if more frequent testing is indicated by the results of the S·O·S Coolant Analysis.

NOTICE
Do not exceed the recommended eight percent supplemental coolant additive concentration.

Add the SCA, If Necessary

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly.
2. If necessary, drain some coolant in order to allow space for the addition of the SCA.
3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic. For the proper concentration of SCA, refer to Special Publication, SEBU6251, “Caterpillar Commercial Diesel Engine Fluids Recommendations”.
4. Clean the cooling system filler cap. Install the cooling system filler cap.

i03645060

Cooling System Water Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime. Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the proper maintenance interval.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE

Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to two articles in the Disassembly and Assembly Manual, “Water Temperature Regulators - Remove and Water Temperature Regulators - Install” for the replacement procedure of the water temperature regulator, or consult your Caterpillar dealer.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i02871204

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

Damage to the crankshaft vibration damper or failure of the damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive torsional vibrations.

A damper that is hot may be the result of excessive torsional vibration, worn bearings, or damage to the damper. Use an infrared thermometer to monitor the temperature of the damper during operation. Follow the instructions that are included with the infrared thermometer. If the temperature reaches 100°C (212 °F), consult your Caterpillar dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, and smooth.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace all of the seals.

Inspect the damper and repair or replace the damper for any of the following reasons.

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Dampers With Sampling Ports

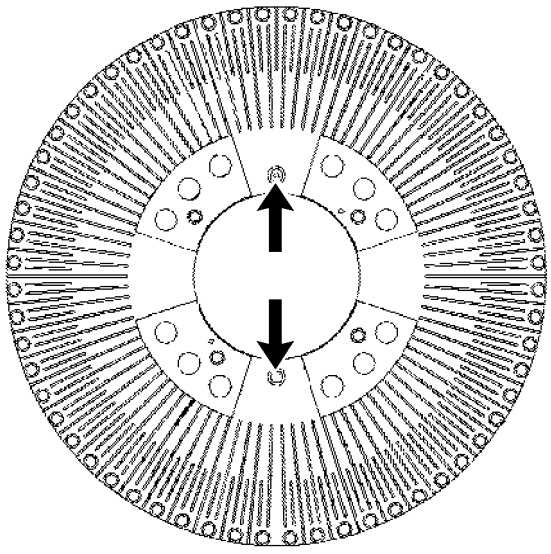


Illustration 57 g00819045

Some dampers have ports for fluid samples. If the damper has no external damage, collect a sample of the damper fluid. The fluid should be analyzed in order to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH
Georg-Knorr-Straße 4
12681 Berlin
Germany
Phone: +49 30 9392-3135
Fax: +49 30 9392-7-3135
Alternate phone: +49 30 9392-3156
Alternate fax: +49 30 9392-7-3156

The typical limit for the degradation of the damper fluid viscosity that is used by Hasse & Wrede GmbH is 20 percent for the majority of applications. The reports from Hasse & Wrede should indicate that the fluid samples meet this viscosity limit.

Dampers Without Sampling Ports

Some dampers do not have a port for a fluid sample. These dampers must be rebuilt or the dampers must be replaced when one of the following criteria has been met:

- The damper has been operated for 20000 hours.
- The engine is undergoing a major overhaul.

Removal and Installation

Refer to the Disassembly and Assembly Manual, “Vibration Damper - Remove and Install” article or consult your Caterpillar dealer for information about damper replacement.

i01664717

Engine - Clean

SMCS Code: 1000-070

WARNING

Personal injury or death can result from high voltage.

Moisture could create paths of electrical conductivity.

Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".

NOTICE
Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

NOTICE
Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: For more information on cleaning and drying electric generators, refer to Special Instruction, SEHS9124, “Cleaning and Drying of Electric Set Generators”.

i01553486

Engine Air Cleaner Element (Dual Element) - Clean/Replace

SMCS Code: 1051; 1054-037

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element. The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable or washable. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element. When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

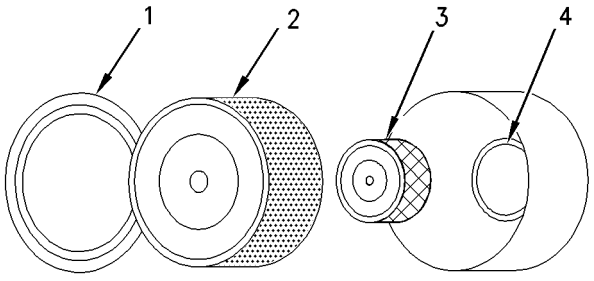


Illustration 58 g00736431

(1) Cover
(2) Primary air cleaner element
(3) Secondary air cleaner element
(4) Turbocharger air inlet

1. Remove the cover. Remove the primary air cleaner element.

2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.

Note: Refer to “Cleaning the Primary Air Cleaner Elements”.

3. Cover the turbocharger air inlet with tape in order to keep dirt out.

4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.

5. Remove the tape for the turbocharger air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.

6. Install the air cleaner cover.

7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The primary air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean primary air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the primary air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean primary air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

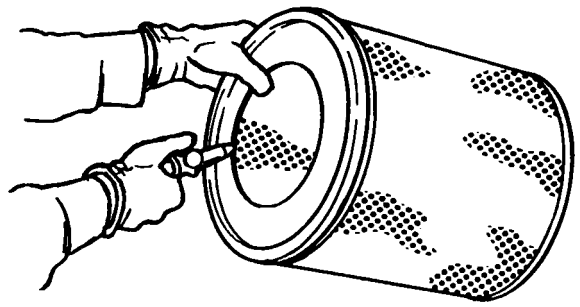


Illustration 59 g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the primary air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

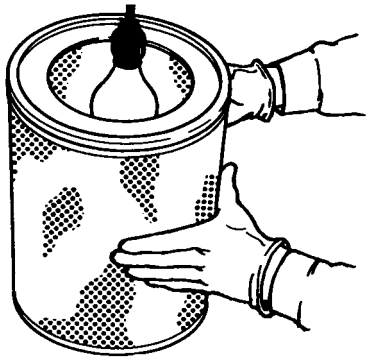


Illustration 60 g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

Storing Primary Air Cleaner Elements

If a primary air cleaner element that passes inspection will not be used, the primary air cleaner element can be stored for future use.

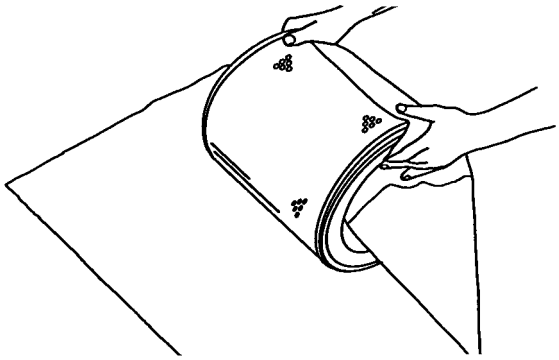


Illustration 61 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the primary air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the primary air cleaner element into a box for storage. For identification, mark the outside of the box and mark the primary air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01553508

Engine Air Cleaner Element (Single Element) - Clean/Replace

SMCS Code: 1051; 1054-037

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent air-borne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application. Consult your Caterpillar dealer for the correct air cleaner element.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Replace the dirty paper air cleaner elements with clean air cleaner elements. Before installation, the air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

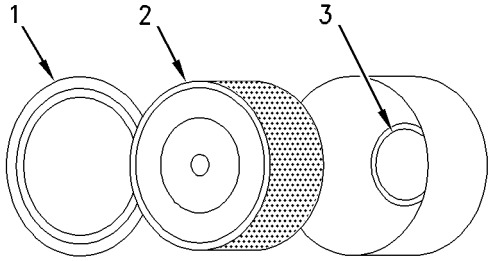


Illustration 62 g00735127

(1) Cover
(2) Air cleaner element
(3) Turbocharger air inlet

1. Remove the air cleaner cover. Remove the air cleaner element.

Note: Refer to “Cleaning the Air Cleaner Elements”.

2. Cover the air inlet with tape in order to keep dirt out.
3. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
4. Remove the tape for the air inlet. Install an air cleaner element that is new or cleaned.
5. Install the air cleaner cover.
6. Reset the air cleaner service indicator.

Cleaning the Air Cleaner Elements

NOTICE
Caterpillar recommends certified air filter cleaning services that are available at Caterpillar dealers. The Caterpillar cleaning process uses proven procedures to assure consistent quality and sufficient filter life.

Observe the following guidelines if you attempt to clean the filter element:

Do not tap or strike the filter element in order to remove dust.

Do not wash the filter element.

Use low pressure compressed air in order to remove the dust from the filter element. Air pressure must not exceed 207 kPa (30 psi). Direct the air flow up the pleats and down the pleats from the inside of the filter element. Take extreme care in order to avoid damage to the pleats.

Do not use air filters with damaged pleats, gaskets, or seals. Dirt entering the engine will cause damage to engine components.

The air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the air cleaner element is cleaned, check for rips or tears in the filter material. The air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

Use clean air cleaner elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the air cleaner elements before cleaning. Inspect the air cleaner elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged air cleaner elements.

There are two common methods that are used to clean air cleaner elements:

- Pressurized air
- Vacuum cleaning

Pressurized Air

Pressurized air can be used to clean air cleaner elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

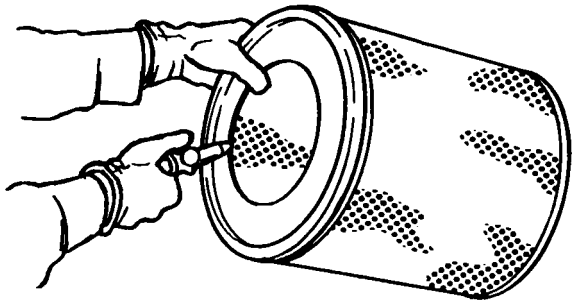


Illustration 63 g00281692

Note: When the air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the air cleaner element. Dirt could be forced further into the pleats.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning air cleaner elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Inspecting the Air Cleaner Elements

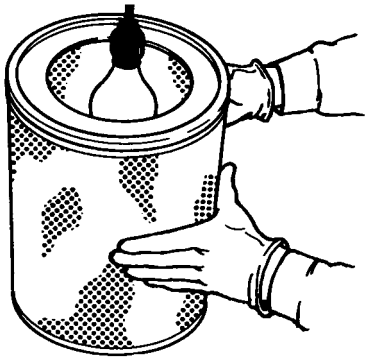


Illustration 64 g00281693

Inspect the clean, dry air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the air cleaner element. Rotate the air cleaner element. Inspect the air cleaner element for tears and/or holes. Inspect the air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the air cleaner element to a new air cleaner element that has the same part number.

Do not use an air cleaner element that has any tears and/or holes in the filter material. Do not use an air cleaner element with damaged pleats, gaskets or seals. Discard damaged air cleaner elements.

Storing Air Cleaner Elements

If an air cleaner element that passes inspection will not be used, the air cleaner element can be stored for future use.

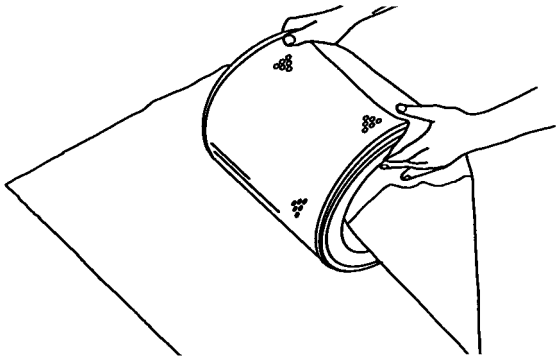


Illustration 65 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. An airflow restriction may result. To protect against dirt and damage, wrap the air cleaner elements in Volatile Corrosion Inhibited (VCI) paper.

Place the air cleaner element into a box for storage. For identification, mark the outside of the box and mark the air cleaner element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the box in a dry location.

i01397712

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

A service indicator may be mounted on the air cleaner element or in a remote location.

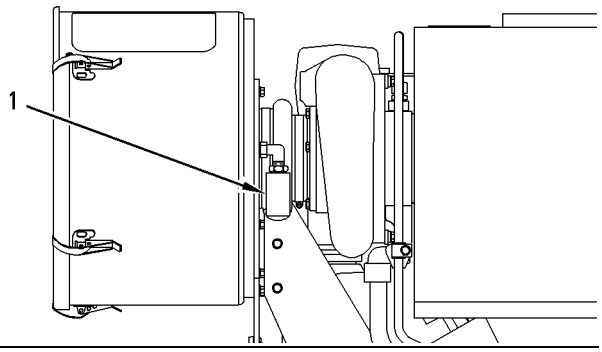


Illustration 66 g00736586

(1) Service indicator

Some engines may be equipped with a different service indicator.

Observe the service indicator. Clean the air cleaner element or replace the air cleaner element when the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.
- The air restriction reaches 6 kPa (25 inches of H_2O).

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated rpm. The yellow core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the fitting for the service indicator may be plugged.

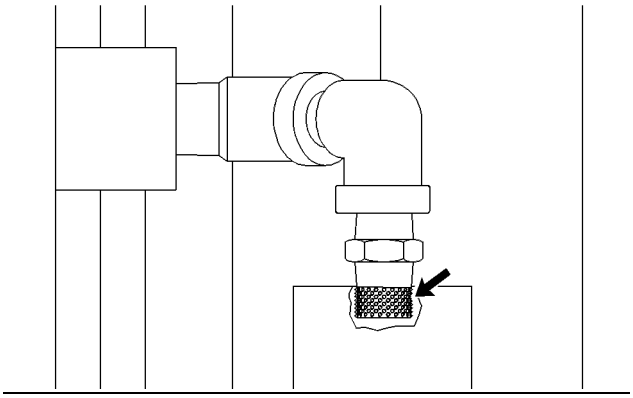


Illustration 67 g00351792

Porous filter

A porous filter is part of a fitting that is used for mounting of the service indicator. Inspect the filter for cleanliness. Clean the filter, if necessary. Use compressed air or a clean, nonflammable solvent.

The service indicator may need to be replaced frequently in environments that are severely dusty, if necessary. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

i01397717

Engine Air Precleaner - Clean

SMCS Code: 1055-070

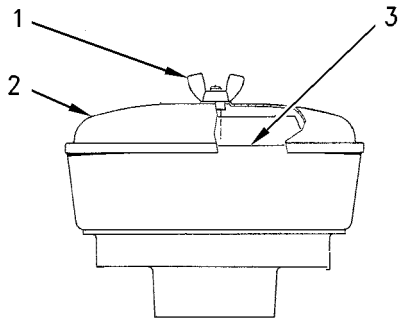


Illustration 68 g00736588

Typical precleaner

(1) Wing nut
(2) Cover
(3) Body

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body, if necessary.

After cleaning the precleaner, install cover (2) and wing nut (1).

Note: When the engine is operated in dusty applications, more frequent cleaning is required.

i01225429

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

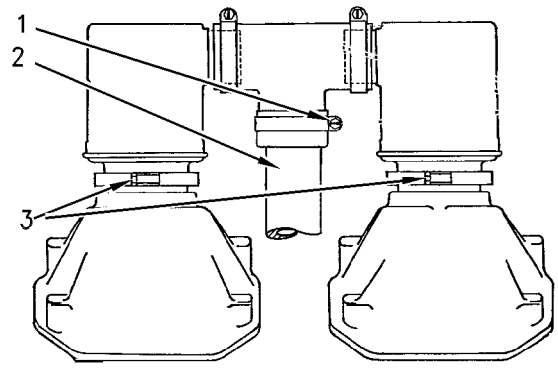


Illustration 69 g00597463

1. Loosen clamp (1). Slide the clamp down on tube (2).

2. Loosen clamps (3). Remove both breathers as a unit.

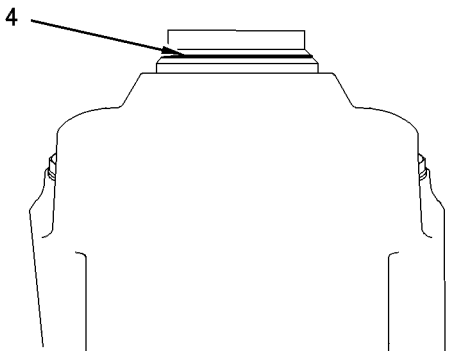


Illustration 70 g00597465

3. Remove O-ring seals (4) from the valve covers. Inspect the O-ring seals for good condition. Obtain new O-ring seals, if necessary.

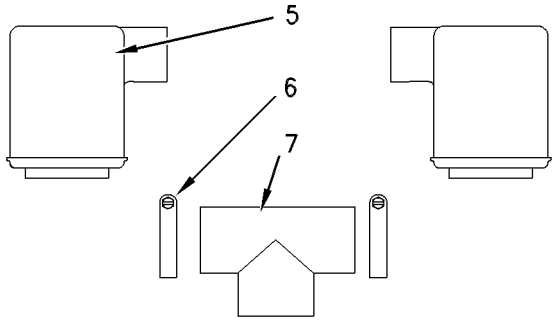


Illustration 71 g00597466

4. Remove two clamps (6). Remove both breathers (5) from hose tee (7).

Inspect the hose tee for cracks. If the tee is cracked, discard the old tee and obtain a new tee for installation.

5. Turn the breathers upside-down in order to inspect the condition of the breather elements.

   Clean the breather elements with clean, nonflammable solvent. If the breather elements remain contaminated after the cleaning, discard the breathers and obtain new breathers. Do not attempt to disassemble the breathers.

   Allow the breather elements to dry before installation.

Note: Coat the rubber parts with clean engine oil or petroleum jelly in order to make installation easier.

6. Place clamps (6) over the parts of hose tee (7) that will receive breathers (5). Install the breathers into the tee. Tighten the clamps to the torque that is listed in the Service Manual, “Specifications”.

7. Coat O-ring seals (4) with clean engine oil. Place the O-ring seals on the valve covers.

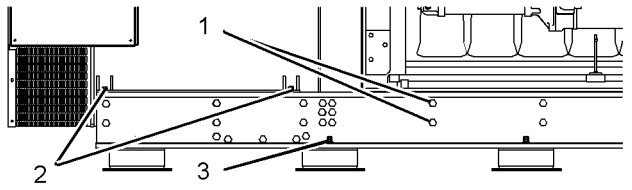
8. Place clamps (3) around the parts of the breathers that will be attached to the valve covers. Install both breathers as a unit. Tighten the clamps.

9. Place clamp (1) on the part of the hose tee that will receive tube (2). Install the tube into the hose tee. Tighten the clamp to the torque that is listed in the Service Manual, “Specifications”.

i03214182

Engine Mounts - Check

SMCS Code: 1152-535



g01340704

Illustration 72

Typical configuration of mounting bolts for a Caterpillar genset

(1) Mounting bolts for the engine
(2) Mounting bolts for the generator
(3) Levelling bolts for the isolators

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting
- Misalignment of driven equipment
- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the proper torque. For standard torques, see Specifications, SENR3130, “Torque Specifications”.

Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for adjusting the isolator are correctly adjusted and secured with the locking nut. Correctly adjusted isolators provide even support for the engine base. Each isolator should impose nearly identical force on the base rail. Each isolator should bear the same portion of the weight of the genset.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators. Also see the Application and Installation Guide for the engine. Consult your Caterpillar dealer for assistance.

i02110431

Engine Oil Filter Differential Pressure - Check

SMCS Code: 1308-535

Observe the oil filter differential pressure frequently during engine operation.

Oil Filter Differential Pressure (Restriction) – This gauge indicates the difference in pressure between the inlet side and the outlet side of the engine oil filters. As the oil filter elements become plugged, oil filter differential pressure will increase.

The nominal oil filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the oil filter elements when the oil filter differential pressure reaches 103 kPa (15 psi).

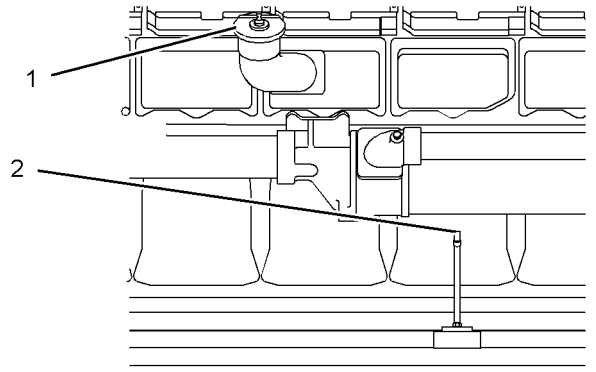
For instructions on replacement of the oil filter elements, see this Operation and Maintenance Manual, “Engine Oil and Filter - Change” topic.

i02418058

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

The most accurate check of the engine oil level is obtained when the engine is stopped.



g01208341

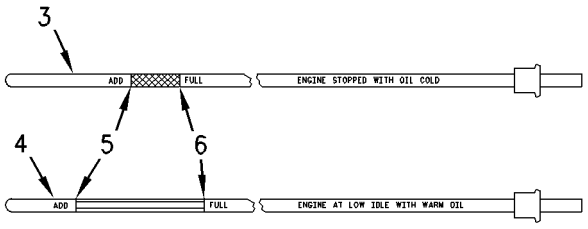
Illustration 73

(1) Filler cap
(2) Engine oil level gauge (dipstick)

1. Remove filler cap (1) in order to ensure that the crankcase pressure is equal to the atmospheric pressure.

Excess pressure or a slight vacuum will affect engine oil level that is measured.

2. Ensure that engine oil level gauge (2) is seated.



g00735162

Illustration 74

(3) “ENGINE STOPPED WITH OIL COLD” side
(4) “ENGINE AT LOW IDLE WITH WARM OIL” side
(5) “ADD” mark
(6) “FULL” mark

a. If the engine is stopped, remove the engine oil level gauge. Observe the engine oil level on “ENGINE STOPPED WITH OIL COLD” side (3).

b. If the engine is operating, reduce the engine speed to low idle. Remove the engine oil level gauge and observe the engine oil level on “ENGINE AT LOW IDLE WITH WARM OIL” side (4).

The engine oil level should be between “ADD” mark (5) and “FULL” mark (6).

NOTICE

Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

3. If necessary, add engine oil. For the correct engine oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section). Do not fill the crankcase above the “FULL” mark on the engine oil level gauge. Clean the filler cap (1). Install the filler cap.

4. Record the amount of engine oil that is added. For the next engine oil sample and analysis, include the total amount of engine oil that has been added since the previous oil change. This will help to provide the most accurate analysis.

i03542996

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine. S·O·S oil analysis provides infrared analysis, which is required for determining nitration and oxidation levels.

Obtain the Sample and the Analysis

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before you take the oil sample, complete the Label, PEEP5031 for identification of the sample. In order to help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 169-8373 Fluid Sampling Bottle is recommended for use with the sampling valve. The fluid sampling bottle includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEgj0047, “How To Take A Good S·O·S Oil Sample”. Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i02345348

Engine Oil and Filter - Change

SMCS Code: 1318-510

Note: Decrease the interval between oil changes by 20 percent and/or increase the API service classification of the oil for engines that operate at high load factors of 80 percent or more for extended periods of time. Refer to Caterpillar Publication, PEDP8025, “S·O·S Fluid Analysis Interpetation Guide” in order to fully understand optimizing oil change intervals.

The oil change interval will be affected by the following items:

- Air/fuel ratio
- Ambient air conditions
- Engine application
- Fuel type
- Oil type
- Size of the oil sump

The S·O·S oil analysis program analyzes used oil in order to determine if the oil change interval is suitable for your specific engine. In the absence of S·O·S oil analysis, change the engine oil and filters according to Table 17.

Table 17

3500 Engine Oil Change Intervals		
Engine	**Sump Capacity**	**Oil Change Interval**
Engines With a Shallow Sump		
3508	104 L (27 US gal)	Every 250 Service Hours
3512	152 L (40 US gal)	
3516	204 L (53 US gal)	
Engines With a Standard Sump		
3508	227 L (60 US gal)	Every 500 Service Hours
3512	318 L (84 US gal)	
3516	405 L (107 US gal)	
Engines With a Deep Sump		
3508	443 L (117 US gal)	Every 1000 Service Hours
3512	625 L (165 US gal)	
3516	807 L (213 US gal)	

Drain the Oil

⚠ WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed when the cold oil is drained. Drain the crankcase when the oil is warm. This method allows proper draining of the waste particles that are suspended in the oil.

Failure to follow this recommended procedure will allow the waste particles to be recirculated through the engine lubrication system with the new oil.

1. After the engine has been operated at normal operating temperature, STOP the engine.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

2. Drain the oil according to the equipment on the engine.

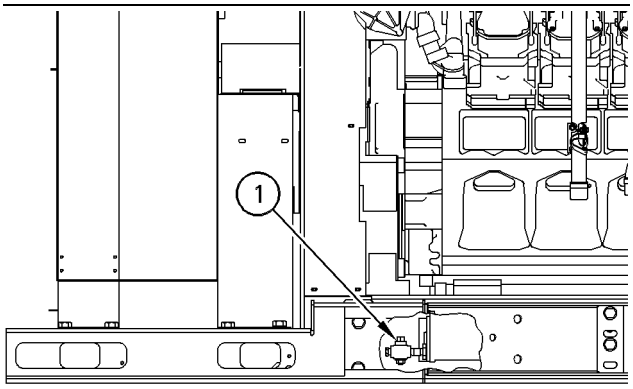


Illustration 75 g00328285

(1) Oil drain

a. Open oil drain (1). After the oil has drained, close the oil drain.

b. If a suction device is inserted into the oil pan, ensure that the suction device is clean. This will prevent dirt from entering into the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.

c. If a suction device that attaches to the oil drain is used, ensure that the suction device is clean. Attach the suction device to the oil drain. Open the oil drain. After the oil has drained, close the oil drain and remove the suction device.

d. If the oil drain valve has a “quick connect” coupling, attach the coupling. Open the drain valve in order to drain the crankcase. After the oil has drained, close the drain valve. Disconnect the coupling.

3. Replace the engine oil filter elements before filling the crankcase with new oil.

Replace the Oil Filter Elements

Replace the engine oil filters when any of the following conditions occur:

- Every oil change
- The engine oil filter differential pressure reaches 103 kPa (15 psi).
- The oil filter elements have been used for 1000 service hours.

Note: Do not attempt to clean the used oil filters. Used oil filters will retain waste particles. The used oil filters would not filter the oil properly.

Service tools are available to aid in the service of oil filters. Consult your Caterpillar dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

Replacing the Engine Oil Filters With the Engine Stopped

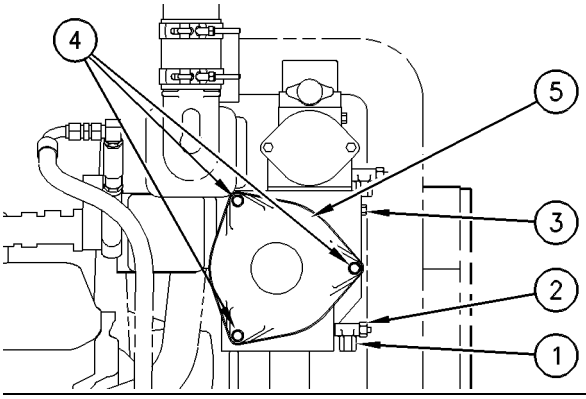
⚠ WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

Perform the following procedure after the oil has been drained.

Note: Use this procedure if the engine oil filters do not have a control valve.



g00328146

Illustration 76

(1) Drain
(2) Drain valve
(3) Plug
(4) Bolts
(5) Cover

Note: Drain the oil into a suitable container. Dispose of the oil according to local regulations.

1. Connect a hose to drain (1). Place the other end of the hose into a suitable container in order to collect the oil.
2. Open drain valve (2). Remove plug (3). Allow the oil to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

Note: Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (5) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

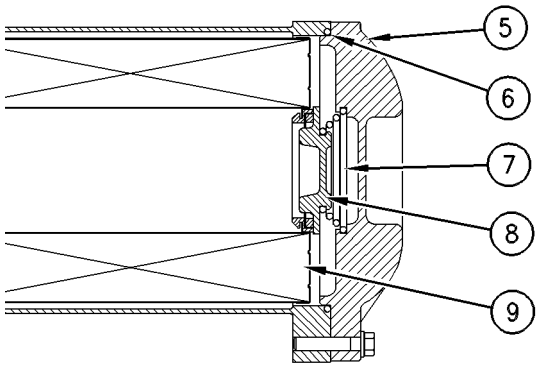
⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

3. Be alert to the spring force. Gradually loosen but do not remove bolts (4). Before removing the bolts, pry the cover (5) loose or tap the cover with a rubber mallet in order to relieve any spring pressure. Remove cover (5).



g00350932

Illustration 77

Section view of the engine oil filter

(5) Cover
(6) O-ring seal
(7) Spring
(8) Retainer
(9) Oil filter element

4. Remove cover (5) and spring (7). Remove O-ring seal (6), retainer (8), and oil filter elements (9).

5. Clean cover (5), spring (7), O-ring seal (6), and retainer (8). Clean the inside of the oil filter housing.

NOTICE
Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

6. Ensure that the new oil filter elements are in good condition. Install the new oil filter elements.

7. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.

8. Install retainer (8), spring (7) and cover (5). Ensure that the retainer and the spring are properly seated between the oil filter elements and the cover.

9. Start the engine according to this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Check for oil leaks.

Replace the Spin-On Oil Filters

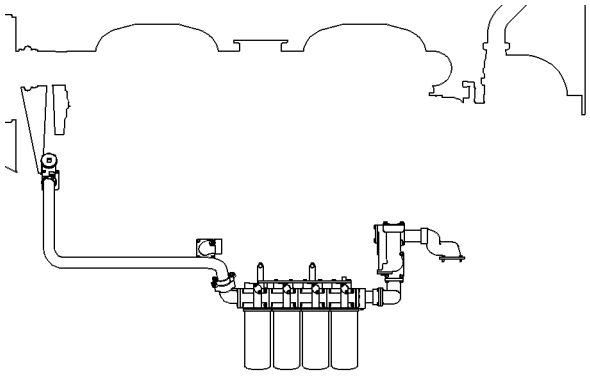


Illustration 78 g00396660
Spin-on oil filters

1. Remove the spin-on oil filter with a 1U-8760 Chain Wrench.

Illustration 79 g00103713
Mounting base and gasket

2. Clean the sealing surface of the mounting base. Ensure that all of the old gasket is removed.

3. Apply clean engine oil to the gasket of the new oil filter.

NOTICE
Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

4. Place the oil filter in position. Tighten the oil filter until the gasket contacts the base. Tighten the oil filter by hand for an additional 1 full turn (360 degrees). Do not overtighten the oil filter.

Replacing the Engine Oil Filters During Engine Operation

If the engine is equipped with duplex oil filters, the engine oil filter elements can be changed while the engine is operation. This is useful if the oil filter elements require more frequent replacement than the engine oil.

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

If rapid air movement exists to blow fluid, Stop the engine to avoid fire.

1. Move the control valve to the “AUX RUN” position in order to change the main oil filter elements. Move the selector valve to the “MAIN RUN” position in order to change the auxiliary oil filter elements.

2. Allow the oil pressure gauge for the oil filter that is being changed to reach a “ZERO” pressure reading.

3. Perform Step 1 through Step 8 of “Replacing the Engine Oil Filters With the Engine Stopped”.

4. Open the “FILL” valve for a minimum of five minutes in order to fill the new oil filter elements.

5. Close the “FILL” valve. Rotate the control valve to the “RUN” position for the oil filter that was serviced.

Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the element. Ferrous metals may indicate wear on the steel and the cast iron parts of the engine. Nonferrous metals may indicate wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Aluminum debris may indicate problems with the bearings of the front gears. If aluminum debris is found, inspect the crankshaft vibration damper and the bearings of the front idler gear.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter element. If an excessive amount of debris is found in the oil filter element, consult your Caterpillar dealer in order to arrange for further oil analysis.

Fill the Crankcase

NOTICE
Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, “Engine Oil” topic (Maintenance Section).

NOTICE
If the engine is equipped with an auxiliary oil filter system, extra oil must be added when filling the crankcase. If equipped with an auxiliary oil filter system that is not supplied by Caterpillar, follow the recommendations of the OEM.

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil's ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

1. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. For the amount of oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities” (Maintenance Section). Clean the oil filler cap. Install the oil filler cap.

NOTICE
To prevent crankshaft or bearing damage, crank engine with fuel off to fill all filters before starting.

Do Not crank engine for more than 30 seconds.

2. Close the fuel supply line and crank the engine until the oil pressure gauge indicates 70 kPa (10 psi). Open the fuel supply line. Allow the starting motor to cool for two minutes before cranking again.

3. Follow this Operation and Maintenance Manual, “Starting The Engine” procedure (Operation Section). Operate the engine at low idle for two minutes. This will ensure that the lubrication system has oil and that the oil filters are filled with oil. Inspect the engine for oil leaks. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.

4. Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.

5. Remove the oil level gauge and check the oil level. Maintain the oil level to the “FULL” mark on the “ENGINE STOPPED” side of the oil level gauge.

i01042067

Engine Performance - Test

SMCS Code: 1000-081

Operate the engine for a minimum of two hours at a minimum load of 60 percent.

- Monitor the operation of the generator set.
- Observe the gauges. Ensure that the gauges are in the normal ranges.
- Record the data. Maintain a record of the data for the engine performance.

i00626013

Engine Protective Devices - Check

SMCS Code: 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

NOTICE
During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

Visual Inspection

Visually check the condition of all gauges, sensors and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

i02939209

Engine Valve Lash - Inspect/Adjust

SMCS Code: 1102-025

Note: For procedures on adjusting the valve lash and adjusting the valve bridge, see System Systems Operation/Testing and Adjusting, “Valve Lash and Valve Bridge Adjustment”. Consult your Caterpillar dealer for assistance.

The initial valve lash adjustment on new engines, rebuilt engines, or remanufactured engines is recommended at the first scheduled oil change. The adjustment is necessary due to the initial wear of the valve train components and to the seating of the valve train components.

WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Valve Bridge

Check the valve bridge and adjust the valve bridge, if necessary. Perform the procedure for both valve bridges for each cylinder. After the valve bridge is checked for each cylinder, proceed with the valve lash adjustment, if necessary.

Engine Valve Lash

NOTICE
Only qualified service personnel should perform this maintenance. Refer to the Systems Operation/Testing and Adjusting Manual, “Valve Lash and Valve Bridge Adjustment” article or consult your Caterpillar dealer for the complete valve lash adjustment procedure.

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

The valve bridge adjustment must be performed before making a valve lash adjustment. If the valve lash is within the tolerance, an adjustment of the valve lash is NOT necessary.

For the valve lash setting, see the engine's Specifications manual. For the procedure to set the valve lash, see the engine's Systems Operation/Testing and Adjusting manual.

i01106228

Fan Drive Bearing - Lubricate

SMCS Code: 1359-086-BD

Note: Lubricate the bearing more frequently if the engine is operated in an environment that is dusty, hot, or humid.

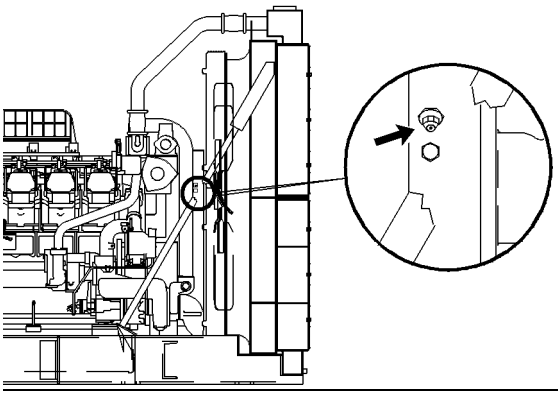


Illustration 80 g00583459

Grease fitting

Fill the grease fitting for the fan drive bearing with Caterpillar Bearing Lubricant. Alternatively, use a multipurpose grease that has three to five percent of molybdenum and a grade of NLGI No. 2.

i01225410

Fuel Injector - Inspect/Adjust

SMCS Code: 1290-025

Note: Perform this procedure when the engine valve lash is inspected.

NOTICE
The camshafts must be correctly timed with the crankshaft before an adjustment of the lash for the fuel injector is made. The timing pins must be removed from the camshafts before the crankshaft is turned or damage to the cylinder block will be the result.

Inspect the adjustment of the lash for the fuel injector according to the Systems Operation/Testing And Adjusting, “Fuel System” topic. Adjust the lash for the fuel injector, if necessary.

i01395213

Fuel System - Prime

SMCS Code: 1250-548; 1258-548

1. Open the fuel supply valve. Ensure that the engine will not start during the priming procedure. Turn the start switch to the OFF position.

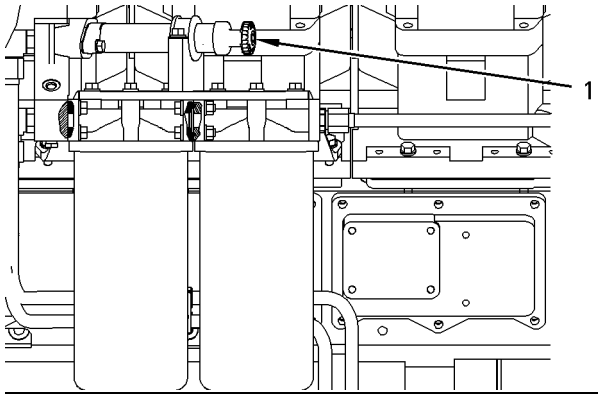


Illustration 81 g00735191

(1) Fuel priming pump plunger

2. Turn fuel priming pump plunger (1) counterclockwise in order to release the lock plate from the retainer.

3. Operate the fuel priming pump until the air in the fuel system has been pumped through the fuel return line back to the fuel tank.

4. Press the fuel priming pump plunger to the locking position. Turn the fuel priming pump plunger clockwise in order to engage the lock plate in the retainer.

Note: Enable the starting system only after all maintenance has been completed.

i01076701

Fuel System Fuel Filter Differential Pressure - Check

SMCS Code: 1261-535

Observe the fuel filter differential pressure frequently during engine operation.

Fuel Filter Differential Pressure (Restriction) – This gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. As the fuel filter element becomes plugged, the difference in pressure between the two sides of the fuel filter increases.

The nominal fuel filter differential pressure during normal engine operation is approximately 60 kPa (9 psi).

Replace the secondary fuel filter elements when the fuel filter differential pressure reaches 103 kPa (15 psi).

For instructions on replacement of the secondary fuel filter elements, see this Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” topic.

i02828884

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

Note: If the engine is equipped with duplex fuel filters, the fuel filter elements can be changed while the engine is in operation. Refer to “Replacing the Fuel Filter Elements During Engine Operation”.

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

Replace the secondary fuel filter elements whenever the following conditions occur:

- The fuel filter differential pressure gauge registers 103 kPa (15 psi).
- The fuel filters have been used for 1000 service hours.

Replacing the Fuel Filter Elements with the Engine Stopped

Canister

1. Stop the engine. Ensure that the engine will not start during this procedure.
2. Shut off the fuel supply valve to the engine.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

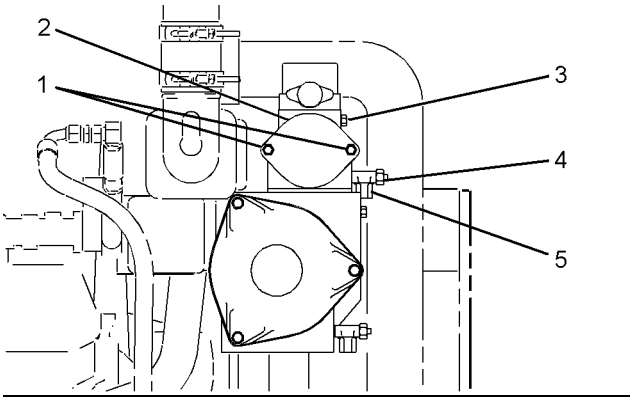


Illustration 82 g01411122

(1) Bolts
(2) Cover
(3) Plug
(4) Drain valve
(5) Drain

3. Connect a hose to drain (5). Place the other end of the hose into a suitable container in order to collect the fuel.
4. Open drain valve (4). Remove plug (3). Allow the fuel to drain. Clean the plug and install the plug. Close the drain valve. Remove the hose from the drain.

Note: Some fuel will remain in the housing after the fuel has been drained. This fuel will pour out of the housing when cover (2) is removed. Prepare to catch the fuel in a suitable container. Clean up any spilled fuel with absorbent towels or pillows. DO NOT use absorbent particles to clean up the fuel.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

5. Be alert to the spring force. Gradually loosen but do not remove bolts (1). Before removing bolts (1), pry cover (2) loose in order to relieve any spring pressure. Remove cover (2). Remove the O-ring seal on the inside of the cover. Remove the fuel filter elements.

6. Clean cover (2) and clean the O-ring seal. Clean the inside of the fuel filter housing.

7. Install new fuel filter elements.

8. Inspect the O-ring seal. Ensure that the surfaces for the O-ring seal are clean. Install a new O-ring seal if the old O-ring seal is damaged or deteriorated.

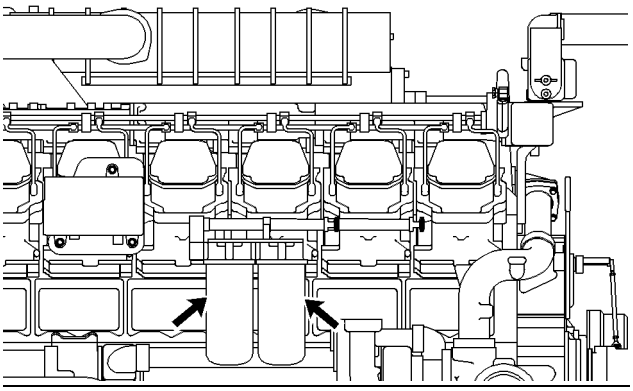
9. Install cover (2). Ensure that the springs are seated properly between the cover and the fuel filter elements.

10. Open the fuel supply valve. Reconnect the battery.

11. Prime the fuel system. Refer to this Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section).

Spin-On Filter

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.



g00425598

Illustration 83
Secondary fuel filters

1. Remove the used fuel filter with a 1U-8760 Chain Wrench. Discard the used fuel filter.

2. Clean the gasket sealing surface of the fuel filter base.

   Ensure that all of the old gasket is removed.

3. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE
Do not fill the fuel filters with fuel before installing the fuel filters. The fuel will not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

4. Install the new fuel filter.

   Spin the new fuel filter onto the fuel filter base until the gasket contacts the base. Tighten the fuel filter by hand by one full turn. Do not overtighten the fuel filter. Use the rotation index marks that are on the fuel filter as a guide for proper tightening.

5. Prime the fuel system.

   See this Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section).

Replacing the Fuel Filter Elements During Engine Operation

If the engine is equipped with duplex fuel filters, the fuel filters can be changed while the engine is in operation.

⚠ WARNING

If the filter is changed during rapid air movement, an explosive vapor may be created. The explosive vapor may result in personal injury or in death.

If rapid air movement exists, stop the engine in order to change the filter.

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

Duplex Fuel Filters

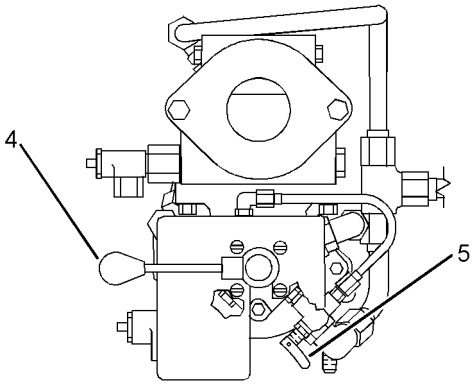


Illustration 84 g01411130

(4) Control valve
(5) Fill valve

1. Open FILL valve (5) for a minimum of five minutes in order to fill the fuel filters that will not be serviced. The fuel filters that will not be serviced must be full of fuel. Close the FILL valve.

2. If the main filter will be serviced, rotate control valve (4) to the “AUX RUN” position.

   If the auxiliary filters will be serviced, rotate control valve (4) to the “MAIN RUN” position.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

3. See “Replacing the Fuel Filter Elements with the Engine Stopped”. Perform Step 3 through Step 9 from the “Canister” instructions.

4. Open fill valve (5) for a minimum of five minutes in order to fill the new elements. Close the fill valve.

   After the new filter elements are full of fuel, either the main filter or the auxiliary filter may be used.

i03645042

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” or refer to Special Publication, PECJ0003, “Caterpillar Shop Supplies and Tools Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Note: Failure to properly close the drain can allow air into the system, which could have detrimental results to performance.

Check the fuel daily. Drain the water and sediment from the fuel tank after operating the engine or drain the water and sediment from the fuel tank after the fuel tank has been filled. Allow five to ten minutes before performing this procedure.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank during the following conditions:

- Weekly
- Oil change
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank. A four micron(c) absolute filter for the breather vent on the fuel tank is also recommended. Refer to Special Publication, SENR9620, “Improving Fuel System Durablity”.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i02346671

Heat Exchanger - Inspect (if equipped)

SMCS Code: 1379-040

⚠ WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The heat exchanger and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove the filler cap slowly to relieve pressure only when the engine is stopped and the filler cap for the heat exchanger is cool enough to touch with your bare hand.

Cooling System Conditioner contains alkali. Avoid contact with skin and eyes.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Shell and Tube Heat Exchanger

The interval for the maintenance of the shell and tube heat exchanger depends on the operating environment and the operating time. The sea water that is circulated through the heat exchanger and the amount of operating time affects the following items:

- Cleanliness of the tubes for the heat exchanger
- Effectiveness of the heat exchanger system

Operating in water that contains the following will adversely affect the heat exchanger system: silt, sediment, salt, and algae. In addition, intermittent use will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature
- Engine overheating
- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection and maintenance of the heat exchanger are required if the engine is overheating.

Cleaning the Shell and Tube Heat Exchanger

The following general guidelines are for cleaning a shell and tube heat exchanger.

1. Drain the heat exchanger.
2. Remove the heat exchanger.
3. Turn the heat exchanger core upside-down in order to remove debris.

NOTICE
Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

4. Back flush the core with cleaner.

   Caterpillar recommends the use of Hydrosolv liquid cleaner. Table 18 lists Hydrosolv liquid cleaners that are available from your Caterpillar dealer.

Table 18

Hydrosolv Liquid Cleaners[1]		
Part Number	**Description**	**Size**
1U-5490	Hydrosolv 4165	19 L (5 US gallon)
174-6854	Hydrosolv 100	19 L (5 US gallon)

(1) Use a two to five percent concentration of the cleaner at temperatures up to 93°C (200°F). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

5. Steam clean the core in order to remove any residue. Flush the tubes of the heat exchanger core. Remove any other trapped debris.
6. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

7. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
8. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.
9. Install the heat exchanger. Refer to the Service Manual for the procedure.

For more information on cleaning the core, consult your Caterpillar dealer.

Plate Type Heat Exchanger

The interval for the maintenance of the plate type heat exchanger depends on the operating environment and the operating time. The sea water that is circulated through the heat exchanger and the amount of operating time affects the following items:

- Cleanliness of the heat exchanger plates
- Effectiveness of the heat exchanger system

Operating in water that contains the following will adversely affect the heat exchanger system: silt, sediment, salt, and algae. In addition, intermittent use will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature
- Engine overheating
- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection of the heat exchanger and maintenance of the heat exchanger are required if the engine is overheating.

Your Caterpillar dealer has the equipment and the personnel in order to measure the pressure drop across the heat exchanger.

Cleaning the Plate Type Heat Exchanger

The following general guidelines are for cleaning a plate type heat exchanger. Refer to Table 19 for types of cleaners.

NOTICE
Do not use hydrochloric acid to clean stainless steel plates.

Do not use hydrofluoric acid to clean titanium plates.

Water that contains more than 300 ppm of chlorine should not be used to prepare cleaning solutions.

Do not use Ketones such as Acetone and Methyletyketone.

Do not use esters such as Ethylacetate and Butylacetate.

Do not use Halogenated hydrocarbons such as Chlorothene and Carbon Tetrachloride

Do not use Aromatics such as Benzene and Toluene.

Table 19

Problem	Source	Cleaners(1)
Scaling	Calcium carbonate Calcium sulphate Silicates	Nitric acid Sulfamic acid Citric acid Phosphoric acid Complexing agents Sodium polyphosphates
Sediment(2)	Corrosion products Metal oxides Silt Diatomic organisms	
Gross fouling	Seaweed Chips of wood and fibers Mussels	
Biological growth	Bacteria Nematodes Protozoa	
Residue	Oily films Asphalt Fats	Paraffinic or Naphtha based solvent such as Kerosene.(3)(4)

(1) Cleaners should be mixed at a maximum concentration of 4 percent by weight. The temperature of the cleaning solution should be less than 60 °C (140 °F).
(2) The addition of surfactants to the cleaning solution may ease cleaning.
(3) Do not mix the solvent with water for cleaning. Dry the plates with a cloth or rinse the plates with water.
(4) Gaskets that are made from natural rubber, butyl rubber and EPDM rubber will swell in these solvents. Do not allow the solvent to contact the gasket more than half an hour.

1. Drain the heat exchanger.
2. Disassemble the heat exchanger and remove the plates. Keep the plates in order.
3. Clean the plates with a cleaning solution and a soft brush. Pressurized water may also be used. Do not use steel wool or a wire brush, which may scratch the plate. Any iron scratches on the plates can lead to corrosion of the plates. Rinse the plates with water.
4. Assemble the heat exchanger.

i02121526

Hoses and Clamps - Inspect/Replace

SMCS Code: 7554-040; 7554-510

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking

- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

NOTICE
Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will heat set. Heat setting causes hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.
4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: Refer to the Specifications, SENR3130, “Torque Specifications” in order to locate the proper torques.

8. Refill the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

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Hoses and Clamps - Replace

SMCS Code: 1380-510

Note: For instructions on draining the cooling system and filling the cooling system, see this Operation and Maintenance Manual, “Cooling System Coolant (DEAC) - Change” topic or see the Operation and Maintenance Manual, “Cooling System Coolant (ELC) - Change” topic (Maintenance Section).

1. Drain the cooling system.

2. Remove the used hoses and clamps. Discard the items.

3. Install new hoses and clamps. For the correct torque to use on the hose clamps, see the Specifications, SENR3130, “Torque Specifications”, “Hose Clamps” topic.

4. Fill the cooling system.

5. Start the engine. Inspect the hose connections for leaks.

i01048507

Instrument Panel - Inspect

SMCS Code: 7451-040

Inspect the instrument panel for good condition. Perform the self-test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

Frequently monitor the gauges during normal operation.

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will help to establish the trends of engine performance. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

i03230758

Jacket Water Heater - Check

SMCS Code: 1383-535

Jacket water heaters help to improve startability in ambient temperatures that are below 21 °C (70 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. Check the operation of the circulation pump, if equipped. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water coolant temperature at approximately 32 °C (90 °F).

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Magnetic Pickups - Clean/Inspect (If Equipped)

SMCS Code: 1907-040

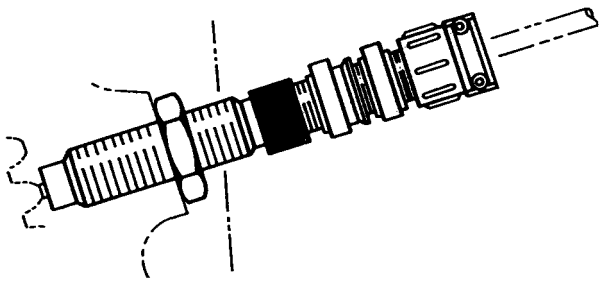

Illustration 85 g00614378

1. Remove the magnetic pickup from the flywheel housing. Check the condition of the end of the magnetic pickup. Check for signs of wear and contaminants.

2. Clean the metal shavings and other debris from the face of the magnet.

3. Install the magnetic pickup until the magnet comes in contact with the flywheel ring gear tooth.

4. Loosen the magnetic pickup by 180 degrees. Tighten the locknut to a torque of 45 ± 7 N·m (33 ± 5 lb ft).

i02345114

Overhaul (Major)

SMCS Code: 7595-020-MJ

Refer to this Operation and Maintenance Manual, “Overhaul Considerations” in order to determine the maintenance interval for a major overhaul.

The need for a major overhaul is determined by several factors.

- An increase of oil consumption
- An increase of crankcase blowby
- The total amount of fuel consumption
- The service hours of the engine
- The wear metal analysis of the lube oil

- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

A major overhaul includes all of the work that is done for the top end overhaul. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

For the major overhaul, all of the bearings, seals, gaskets, and components that wear are disassembled. The parts are cleaned and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Caterpillar replacement part.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

The following definitions explain the terminology for the services that are performed during an overhaul:

Inspect – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

Rebuild – The component can be reconditioned in order to comply with reusability guidelines.

Replace – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 20. Your Caterpillar dealer can provide these services and components.

Table 20

Major Overhaul Instructions (1)	
Clean	Oil suction screen
Clean Inspect Test	Aftercooler core (2)
Inspect	Camshafts
	Cylinder block
	Crankshaft vibration damper
	Driven equipment (alignment)
	Flywheel
	Front gear train (gears)
	Fuel system linkage
	Rear gear train (gears)
Inspect Rebuild	Rocker arms
Inspect Rebuild Replace	Connecting rods
	Cylinder head assemblies
	Fuel priming pump
	Fuel transfer pump
	Oil cooler core
	Piston pins

(continued)

(Table 20, contd)

Major Overhaul Instructions (1)	
Inspect Replace	Camshaft lifters
	Camshaft thrust washers
	Crankshaft
	Cylinder liners
	Engine mounts
	Engine wiring harness
	Fuel pressure regulating valve
	Pistons (Crowns and Skirts)
	Pushrods
	Spacer plates
Replace	Camshaft bearings
	Connecting rod bearings
	Crankshaft seals
	Crankshaft thrust plates
	Fuel injectors
	Gear train bushings
	Main bearings
	Piston rings
	Seals and bellows for the exhaust manifold
	Seals and gaskets for the air Inlet manifold

(1) For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.
(2) For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” topic.

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Overhaul (Top End)

SMCS Code: 7595-020-TE

Refer to this Operation and Maintenance Manual, “Overhaul Considerations” in order to determine the maintenance interval for a top end overhaul.

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. A few additional components are replaced and serviced.

The top end overhaul (second interval) involves the same service that is performed for the first interval. Because of the number of service hours, some additional components are inspected and/or serviced.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

The following definitions explain the terminology for the services that are performed during an overhaul:

Exchange – Your Caterpillar dealer will exchange your worn parts for parts that conform to original functional specifications.

Inspect – Inspect the components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. The guidelines were developed in order to help Caterpillar dealers and customers to avoid unnecessary expenditures. New parts are not required if the existing parts can still be used, reconditioned, or repaired. If the components are not in the reusability guidelines, refer to the Service Manual, “Specifications” module.

Install New – The service life of the part is exhausted. The part cannot be reconditioned. The replacement part must be a new part.

Rebuild – The component is reconditioned in order to comply with reusability guidelines.

Replace – The service life of the part is exhausted. The part may fail before the next maintenance interval. The part must be replaced with a part that meets functional specifications. The replacement part may be a new part, a CAT remanufactured part, a rebuilt part, or a used part. Some worn components may be exchanged with your Caterpillar dealer for credit on replacement parts. Consult your Caterpillar dealer about repair options for your engine.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the recommendations in Table 21 and Table 22.

Table 21

Top End Overhaul (1)

(continued)

(Table 21, contd)

Clean	Oil suction screen
Clean Inspect Pressure test	Aftercooler core (2)
Exchange Install new	Fuel injectors
Inspect Install new	Engine wiring harness
Inspect Rebuild	Rocker arms
Inspect Rebuild Exchange	Cylinder head assemblies
	Fuel priming pump
Inspect Replace	Fuel pressure regulating valve
	Pushrods
	Spacer plates
Install new	Air inlet manifold (gaskets and seals)
	Exhaust manifold (seals and bellows)

(1) For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.

(2) For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” topic.

Table 22

Second Top End Overhaul (1)	
Clean	Oil suction screen
Clean Inspect Pressure test	Aftercooler core (2)
Exchange Install new	Fuel injectors
Inspect Exchange	Camshaft lifters
Inspect	Connecting rod bearings (3)
	Cylinder liners (3)
	Piston crowns and skirts (3)
	Piston pins (3)
Inspect Install new	Camshaft lifters
	Engine wiring harness
Inspect Rebuild Exchange	Cylinder head assemblies
	Engine oil pump
	Fuel priming pump
	Fuel transfer pump
	Prelube pump
	Scavenge oil pump
Inspect Replace	Fuel pressure regulating valve
	Pushrods
	Spacer plates
Inspect Rebuild	Rocker arms
Install new	Air inlet manifold (gaskets and seals)
	Exhaust manifold (seals and bellows)
Rebuild Exchange	Turbochargers

(1) For instructions on removal and installation of components, see the Service Manual, “Disassembly and Assembly” module.

(2) For instructions on cleaning the core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” topic.

(3) Inspect ONLY TWO of the components from each cylinder bank. This inspection will provide adequate examples of the condition of the other corresponding components.

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Overhaul Considerations

SMCS Code: 7595-043

Severe Operation

Severe operation is the use of an engine that exceeds current published standards for that engine. Caterpillar maintains standards for the following engine parameters:

- Horsepower
- Range of rpm
- Fuel consumption
- Fuel quality
- Altitude
- Maintenance intervals
- Selection of oil
- Selection of coolant
- Environmental qualities
- Installation

Refer to the standards for your engine or consult your Caterpillar dealer in order to determine if your engine is operating within the defined parameters.

Severe operation can accelerate component wear. Engines that are operating under severe conditions may need more frequent maintenance intervals for the following reasons:

- Maximum reliability
- Retention of full service life

Because of individual applications, it is not possible to identify all of the factors which can contribute to severe operation. Consult your Caterpillar dealer about the maintenance that is needed for your specific engine.

The following factors can contribute to severe operation: environment, improper operating procedures, and improper maintenance practices.

Environmental Factors

Extreme Ambient Temperatures

Extended operation in environments that are extremely cold or hot can damage components. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot inlet air reduces the performance capabilities of the engine.

Note: See this Operation and Maintenance Manual, “Cold Weather Operation” topic (Operation Section), or see Supplement, SEBU5898, “Cold Weather Recommendations”.

Cleanliness

Unless the equipment is cleaned regularly, extended operation in a dirty environment and in a dusty environment can damage components. Built up mud, dirt, and dust can encase components. This can make maintenance difficult. The buildup can contain corrosive chemicals. Corrosive chemicals and salt can damage some components.

Improper Operating Procedures

- Extended operation at low idle
- Minimum cool down periods after high load factor operation
- Operating the engine beyond the guidelines for the engine rating
- Operating the engine at loads that are greater than the rated load
- Operating the engine at speeds that are greater than the rated speed
- Use of the engine for an application that is not approved

Improper Maintenance Practices

- Extension of maintenance intervals
- Not using recommended fuel, lubricants, and antifreeze/coolant

Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul interval is a maintenance interval that is planned. The engine is rebuilt with certain rebuilt parts or new parts that replace the worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed
- Cleaning of the internal passages of the engine and the engine block

Most owners will save money by overhauling the engine at the intervals that are recommended in this Operation and Maintenance Manual. Consider the graph in Illustration 86.

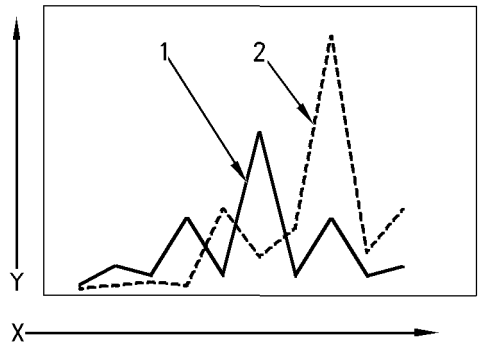

Illustration 86 g00745964

(Y) Cost
(X) Time
(1) Cost of maintenance and repair that is planned
(2) Cost of maintenance and repair that is not planned

In Illustration 86, line (1) represents the maintenance and repair costs for an owner that followed the recommendations for inspection, maintenance, and repair. The peaks represent overhauls.

Line (2) represents the maintenance and repair costs for an owner that chose to operate beyond the recommended intervals. The initial cost of the “repair-after-failure” philosophy is lower. Also, the first overhaul was delayed. However, the peaks are significantly higher than the peaks for the customer that used the “repair-before-failure” philosophy .

The higher peaks result from two key factors:

- Delaying an overhaul until a breakdown increases the chance of a catastrophic failure. This type of failure requires more parts, labor, and cleanup.
- Excessive wear means that fewer components will be reusable. More labor may be required for salvage or repair of the components.

When all of the costs are considered, “repair-before-failure” is the least expensive alternative for most components and engines.

It is not practical to wait until the engine exhibits symptoms of excessive wear or failure. It is not less costly to wait. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.
- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

Overhaul Intervals

Some factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Proper installation
- Operating conditions
- Operation within acceptable limits
- Engine load
- Engine speed

Generally, engines that are operated at a reduced load and/or speed achieve more service life before an overhaul. However, this is for engines that are properly operated and maintained.

Other factors must also be considered for determining a major overhaul:

- The total amount of fuel consumption
- The service hours of the engine
- An increase of oil consumption
- An increase of crankcase blowby
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

Using Fuel Consumption For Calculating the Overhaul Intervals

Experience has shown that maintenance intervals are most accurately based on fuel consumption. Fuel consumption corresponds more accurately to the engine load. Tables 23, 24, and 25 list average ranges of fuel consumption for a load factor of approximately 60 percent.

Table 23

Maintenance Intervals for Overhaul Fuel Consumption for 3508 and 3508B Engines	
Top End Overhaul	976,000 L (257,500 US gal)
Second Top End Overhaul	1,952,000 L (515,000 US gal)
Major overhaul	2,928,000 L (772,500 US gal)

Table 24

Maintenance Intervals for Overhaul Fuel Consumption for 3512 and 3512B Engines	
Top End Overhaul	1,460,000 L (385,000 US gal)
Second Top End Overhaul	2,920,000 L (770,000 US gal)
Major Overhaul	4,380,000 L (1,155,000 US gal)

Table 25

Maintenance Intervals for Overhaul Fuel Consumption for 3516 and 3516B Engines	
Top End Overhaul	1,942,000 L (512,500 US gal)
Second Top End Overhaul	3,884,000 L (1,025,000 US gal)
Major Overhaul	5,826,000 L (1,537,500 US gal)

Table 26

Equation For Calculating Overhaul Intervals
F/R = H
“F” is the estimated total amount of fuel consumption of the engine.
“R” is the rate of fuel consumption in liters per hour or gallons per hour.
“H” is the number of estimated hours until the overhaul interval.

Use the actual records of fuel consumption, when possible. If the actual records are not available, use the following procedure in order to estimate the fuel consumption.

1. Estimate the average percent of the load for the operation of the engine.

2. Refer to the fuel consumption data in the Technical Marketing Information (TMI) for your engine. This will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure as variable “F” for the equation in Table 26. For more information about the Technical Marketing Information (TMI) for your engine, consult your Caterpillar dealer.

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine's oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Inspection

Refer to the Service Manual for the disassembly and assembly procedures that are necessary in order to perform the required maintenance on the items that are listed. Consult your Caterpillar dealer for assistance.

To determine the reusability publications that are needed to inspect the engine, refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”.

The Guidelines For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed in order to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts. If the engine parts comply with the established inspection specifications, the parts can be reused.

The use of out-of-spec parts could result in unscheduled downtime and/or costly repairs. The use of out-of-spec parts can also contribute to increased fuel consumption and reduction of engine efficiency. New parts are not necessary if the old parts can be reused, repaired, or salvaged. Otherwise, the old parts can be replaced or exchanged.

Your Caterpillar dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

Overhaul Programs

An economical way to obtain most of the parts that are needed for overhauls is to use Caterpillar remanufactured parts. Caterpillar remanufactured parts are available at a fraction of the cost of new parts. These parts have been rebuilt by Caterpillar and certified for use. The following components are examples of the remanufactured parts:

- Cylinder heads
- Oil Pumps
- Turbochargers
- Water pumps

Consult your Caterpillar dealer for details and for a list of the remanufactured parts that are available.

Your Caterpillar dealer may be offering a variety of overhaul options.

A Flat Rate Overhaul guarantees the maximum price that you will pay for an overhaul. Flat rate prices on preventive maintenance programs or major repair options are available from many servicing dealers for all Caterpillar Engines. Consult your Caterpillar dealer in order to schedule a before failure overhaul.

Overhaul Recommendation

Caterpillar recommends a scheduled overhaul in order to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Caterpillar dealer.

Overhaul programs vary between dealers. To obtain specific information about the types of overhaul programs and services, consult your Caterpillar dealer.

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Radiator - Clean

SMCS Code: 1353-070

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the radiator, if necessary.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a “comb”. Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

For more detailed information on cleaning and inspection, refer to Special Publication, SEBD0518, “Know Your Cooling System”.

i02346696

Sea Water Strainer - Clean/Inspect (if equipped)

SMCS Code: 1371-040; 1371-070

The sea water strainer must be clean in order to allow proper engine cooling. Check the sea water strainer for plugging. Inspect the sea water strainer more frequently in conditions with shallow water or dirty water. Refer to the OEM recommendations for more information about inspecting and cleaning the sea water strainer.

i01038735

Standby Generator Set Maintenance Recommendations

SMCS Code: 4450-041

A standby generator set may not need to be used very often. However, the generator set is usually needed for operation in an emergency situation. Maintenance of the standby generator set is very important for the following reasons:

- The generator set must always be in excellent operating condition.
- The generator set must be ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide these benefits:

- Maximum availability of the standby generator set
- Longer service life for the generator set
- Minimum of expensive repairs

Your Caterpillar dealer can help you to establish an effective Preventive Maintenance Program for your generator set. Consult your Caterpillar dealer for details.

Maintenance and Operation Procedures

⚠ WARNING

The high voltage that is produced by an operating generator set can cause severe injury or death. Before performing any maintenance or repairs, ensure that the generator will not start.

Place the engine control switch in the "OFF" position. Attach "DO NOT OPERATE" tags to all starting controls. Disconnect the batteries or disable the starting system. Lock out all switchgear and automatic transfer switches that are associated with the generator.

The recommended maintenance for the engine is listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule (Standby Generator Set Engines)" (Maintenance Section).

For the recommended generator maintenance, see the Operation and Maintenance Manual for the generator and the control panel.

Maintenance and Repair

The maintenance that is recommended for Every Week can be performed by an authorized operator. The maintenance that is recommended for the subsequent maintenance intervals must be performed by an authorized service technician or by your Caterpillar dealer.

Unless other instructions are provided, perform maintenance and repairs under the following conditions:

- The engine is stopped.
- The starting system is disabled.
- The generator does not pose an electrical shock hazard.

Operation

To ensure proper operation, the generator set must be exercised regularly. For instructions on operating the generator set, see the Operation and Maintenance Manual for the generator set control panel.

For these operation procedures, follow the instructions that are provided in this Operation and Maintenance Manual, "Operation Section": starting the engine, engine operation, and stopping the engine.

Record Keeping

Maintain a record in order to document these items: gauge readings, maintenance that is performed, problems, and repairs.

Space Heaters

Moisture causes damage to generators and other electrical equipment. Make every effort to keep the generator set as dry as possible.

Generators can operate without problems in humid environments. However, problems can occur when the generator is inactive. Moisture can condense on the windings. This can result in poor performance. Also, damage to the windings can occur.

Use space heaters in order to help keep the windings dry. When the generator is not active, ensure that the space heaters are operating. When the generator is operating, turn OFF the space heaters.

i01113939

Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

Electric Starting Motor

Note: Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Make repairs, if necessary.

Air Starting Motor

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue causing serious injury, and possible death.

If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Inspect all of the components in the air circuit for the starting motor. Inspect all of the air lines and connections for leaks.

If the teeth of the starting motor pinion and/or the flywheel ring gear are damaged, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

Removal and Installation of the Starting Motor

Refer to the Service Manual, “Disassembly and Assembly” module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance.

i01261768

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side).

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.
2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the turbocharger wheel and the turbocharger housing, the turbocharger should be reconditioned or replaced.
3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.
4. Inspect the bore of the turbine housing for corrosion.
5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.
6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i02155206

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks, coolant leaks, exhaust leaks, loose bolts, worn belts, loose connections and trash buildup. Make repairs, as needed:

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

Note: Use care when you use steam cleaning. Use care when you use high pressure water. Direct spray to rotating electrics or electronic components can cause nonfixable damage.

NOTICE
Water and/or condensation can cause damage to electrical components. Protect all electrical components from exposure to water.

- Ensure that the coolant lines are properly clamped. Ensure that the fittings are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pump and the installation of water pump and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the following locations: front crankshaft seal, rear crankshaft seal, oil pan, oil filters, valve cover, turbocharger, external oil lines, and connections.
- Inspect the fuel system for leaks. Look for loose fuel line clamps or connections.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps or connections.
- Ensure that the exhaust system is properly clamped. Ensure that the connections are tight. Check for leaks. Check the condition of all connections and components of the exhaust system.
- Inspect the alternator belt and the accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Inspect the engine-to-frame ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges which are cracked. Replace any gauges that can not be calibrated.

i01105559

Walk-Around Inspection (Exercise Inspection of Standby Generator Set Engines)

SMCS Code: 1000-040

1. Perform the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” topic (Operation Section).
2. Start the engine according to the instructions in this Operation and Maintenance Manual, “Engine Starting” topic (Operation Section).

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

3. Perform an inspection of the installation after the engine is started. Look for leaks. Listen for unusual noises.

   - Check the engine oil level when the engine is operating at low idle rpm. Observe the oil level on the “LOW IDLE” side of the oil level gauge (dipstick).
   - Inspect the lubrication system for leaks at the oil pan, the oil filter, and the valve covers.
   - Inspect the cooling system for leaks at the hose connections.
   - Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
   - Inspect the exhaust system for leaks.
   - If the enclosure has louvers, inspect the louvers for proper operation.
   - Observe the gauges. Ensure the correct readings for the engine rpm. Record the data for the gauges.
   - Record the data for the performance of the generator. See the Operation and Maintenance Manual for the generator and the control panel.

4. After exercising the generator set, stop the engine according to this Operation and Maintenance Manual, “Engine Stopping” topic (Operation Section).

5. Perform the procedures that are described in this Operation and Maintenance Manual, “After Stopping Engine” topic (Operation Section).

6. Ensure that the control switches are in the correct position for automatic starting of the generator set.

i02624237

Water Pump - Inspect

SMCS Code: 1361-040

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Disassemble and Water Pump - Assemble” for the disassembly and assembly procedure. If it is necessary to remove the water pump, refer to two articles in the Disassembly and Assembly Manual, “Water Pump - Remove and Water Pump - Install”.

Inspect the water pump for wear, cracks, pin holes and proper operation. Refer to the Parts Manual for the correct part numbers for your engine or consult your Caterpillar dealer if repair is needed or replacement is needed.

i03028045

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in the following issues: premature deterioration of cooling system components, leaks, and possible cooling system contamination. The corrosion may be caused by the lack of zinc rods in the sea water system.

Zinc rods are installed in the sea water cooling system of the engine in order to help prevent the corrosive oxidation that is caused by sea water. Electrical current is conducted through the contact of the zinc rods with the cooling system components. The zinc rods oxidize rather than the cooling system components. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or improperly grounded electrical attachments.

The engineer for the operation must determine the interval for inspecting the zinc rods. The interval for inspecting the zinc rods will depend on the size of the zinc rods and the number of zinc rods that are installed.

Table 27

Locations of the Zinc Rods	
Location	**Quantity**
Elbow of the Auxiliary Water Pump	1
Elbow of the Aftercooler	1

Inspect the Zinc Rods

1. Remove the zinc rod.

2. Inspect the zinc rod.

Ensure that the zinc rod will remain effective until the next scheduled inspection.

a. If the zinc rod has deteriorated excessively, install a new zinc rod.

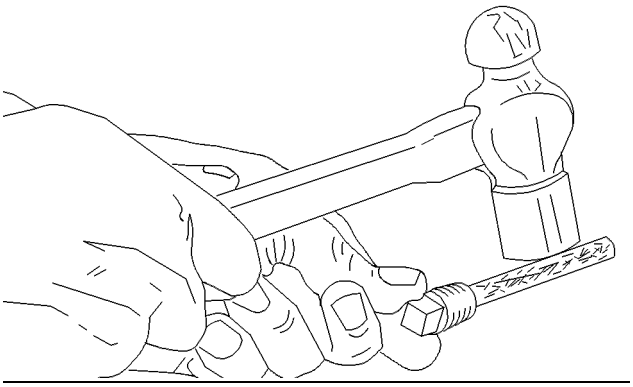

Illustration 87 g00481100

b. Tap the zinc rod lightly with a hammer. If the zinc rod breaks, install a new zinc rod.

3. If the zinc rod will be reused, scrape the layer of oxidation from the zinc rod before installation. The layer of oxidation reduces the effectiveness of the zinc rod.

Replace the Zinc Rods

1. Use pliers to unscrew the old zinc rod from the plug.

If not enough material remains or the zinc rod has broken off, drill the zinc from the plug.

2. Clean the plug.

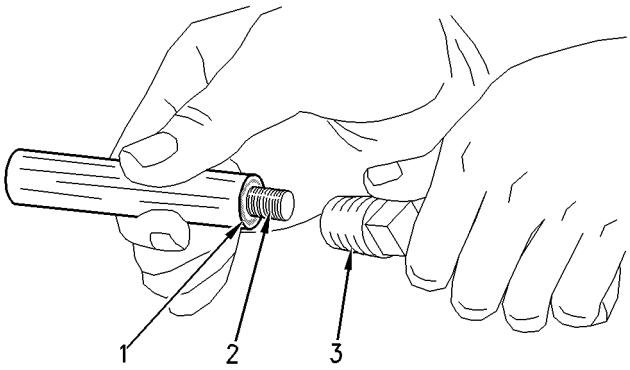

Illustration 88 g00748510

(1) Shoulder
(2) Threads
(3) External threads of the plug

Note: Do not apply adhesive or sealant to the threads of the zinc rod (2).

3. Apply 9S-3263 Thread Lock Compound to the shoulder (1) of a new zinc rod. Apply the compound only to the shoulder of the zinc rod. Install the zinc rod onto the plug.

4. Coat the external threads of the plug (3) with 5P-3413 Pipe Sealant. Install the zinc rod. See Specifications, SENR3130, “Torque Specifications” for the torque for the plug.